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R I C K E T S.

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R I C K E T S

I N T R O D U C T I O N

I have had numerous opportunities for observing and studying rickets in its varied and protean manifestations; and from the very first have been impressed with the frequency with which the affection occurs, as well as the profundity of its general and special effects. I have given close attention to its cause, or causes - the discussion of which will be entered upon in due course. The importance of this disease is undoubted; so great is it, indeed, that it behoves everyone in practice to become thoroughly acquainted with it, its influence upon the infantile death-rate being enormous and its presence or absence a most important factor in the prognosis of all children's ailments. The idea raised in the mind of the student of this disease is that of a deformed osseous system; and this is doubtless a well-marked feature in established cases. But it is a late one, and it is often on account of some deformity that the mothers first seek advice. Nevertheless, it not infrequently happens that she calls in the medical attendant on account of some gastric anomaly or intestinal trouble, and never for a moment suspects the presence of the parent rachitic disease. When I come to think of the facilities of observation and experiment presented by rickets, I am surprised to find how few observe or have recourse to experiment. Observation is an art which can only be acquired by practice; but it is an art also, however well acquired, that soon falls into abeyance from carelessness or lack of interest; and it is evident that the faculty for observation, thus blunted, materially hinders a correct diagnosis. In that case the treatment will be faulty, and the prognosis also, of course. We are all well aware of the fact that tuberculosis of the lungs is amenable to a well-directed therapy, if its early manifestations are recognised; and it is of just as much importance that the early symptoms of disease like rickets should be understood. But, it might be asked, why in this way compare rickets, - a preventible, if not the most preventible of diseases, - with phthisis pulmonalis. The answer is, - and experience proves it, - that the havoc of the former on infantile life is in no way less than the latter at a later period, and that both tend, under favourable circumstances, to end in recovery. This view coincides with facts both clinical and pathological; and everyone can bear witness to it from cases encountered at one time or another during the ordinary course of practical experience. I hold, then, that a careful study of pediatrics is most essential to every student - the more so when we consider the high percentage of patients which this section of the community affords. It has been said that children constitute at least one-third of all patients. That this is a low estimate is borne out by all general practitioners. From the proficiency of the latter in this branch of medicine their ability will be measured by the general public, and their reputation may directly

depend thereon.Although rickets is essentially a disease of children,as a rule,it is justifiable to conjecture what relics it bequeaths as heritages for adult life,and also what part the latter play in the evolution of subsequent ailments.The literature of the disease is enormous;and the perusal of it,together with a considerable observation of cases,will constitute a subject of great interest and fascination.Experiment is,of course,in its widest sense at least,beyond the possibilities of the general prqctitioner,being more or less the field of the specialist.In its limited sense,however,it is open to all;and it is wonderful,if one takes pains,how useful even small experiments may become.Nature herself also provides us with not a few striking illustrations,which are of great advantage in connection with this disease. In these days of social reform,with all the numerous and varied indications of increased public interest in the housing of the people,in the accumulating knowledge of the dangers of suckling women working in factories and mills,with the conviction of the absolute necessity for the proper feeding of children,especially in the earlier years,the medical inspection of school children,the provision of meals for the necessitous in the elementary schools,and the formation of district and village nursing associations,rickets is a subject of great interest and attention-holding importance,covering,as it does,the while question of healthier homes,improved sanitation, purer,better,and more abundant food:in short,the building up of an ideal community.The affection is also of a peculiar widespread character,being encountered in the children of the slums as well as in those of the country places;it is prevalent in the nurseries of the rich,being there referable to either ignorance or carelessness.It is a distinct affection,although its history does not go so far back as that of certain other maladies.Its protean character is evident from the literary accumulations dealing with its evolution,mention therein being made of such conditions as deformities of bone,gastrointestinal disturbances,retardation of dentition,weakness of muscles and ligaments,and nervous disorders.Its peculiarities indicate clearly the necessity for its thorough comprehension;for,although seldom fatal of itself,it is a grave menace to children,and,especially in its more severe forms,leaves its imprint upon the body,as evidenced by stunted growth and deformed limbs,and the well-known rickety pelvis,so fruitful a source of difficulty and danger and disaster in childbed.One cannot be surprised that so many of the rural population (who should be the backbone of our race),disgusted with their surroundings and the depressing monotony of their lives,forsake their country existence and make for the disease-producing towns, when we consider how many cottage-hovels are to be seen in the country,which were built,perhaps nearly a hundred years ago,far short of the minimum standard of comfort and decency,and are dark,unventilated,damp,and dismal habitations.Some three years ago,Allbutt delivered an address in the course of which he dealth withthe relation between medicine and the State,and offered the nation a remedy for many of its evils,namely,the establishment of a general staff of medicine"to rebuke the purblind and inveterate habit of our countrymen of devoting their magnificent energy and their treasure in mopping up effects in disregard of causes"He adds that "we pour out money like water in order to found sanatoria for consumption,asylums for the insane,prisons for

the criminal,yet are moved with the greatest difficulty to subscribe to the agencies which study to prevent those evils...At present it is nobody's business to educate the public in those rules of life and living which are the springs of national efficiency!"The functions of medicine have been too long neglected by the "unidea'd governing classes",and a ministry of public health can alone deal with the work outlined in his address.This "immense and beneficient work would include the protection of infant life;the medical inspection of school children;the physical and mental conditions of education; the conditions of labour,the dynamics of food,and the minimum wage;factory inspection,with estimates of the effects of different trades upon health,and collateral problems of compensation;housing,ventilation,and sanitation;food markets and adulteration;epidemic diseases;the working of the Poor Law;the campaign against drunkenness,fornication,and other social vices;criminology,and punishment,and the 'antiquated and distrusted dogmas of the judges of the higher courts on responsibility before the law'"".In further testimony of the interest and importance of the subject I may quote the words of John Bishop,in a lecture delivered in 1848,which have made a great impression on me:"It has been imagined,"he remarks, "that rickets is a disease peculiar to England;but the statistics of French writers,and the number of squalid, rickety forms seen running in the streets of Amsterdam, show that the populations of other countries do not entirely escape this fearful malady.If we search for the causes by which the disease is generated,we find that it most frequently occurs among persons living in low,dark, damp,filthy cellars,and ill-ventilated and over-crowded dwellings,such as may be found in many parts of the metropolis,where they are not only ill-fed and ill-clothed, but are also denied the enjoyment of a due supply of the great physical agents of life,- namely,light,heat,pure air,and water.When a great number of persons live in the circumstances just mentioned,it cannot excite surprise that their constitutions should be subject to various derangements,and amongst them ~~to~~ that of rickets.Cases of this kind,however,occur in the families of the opulent,who are exempt from the ordinary disadvantages just described;and hence,a large field of inquiry is laid open.What are the exact external conditions,and internal predispositions,which are necessary to engender this specific form of disease,is a problem yet to be solved, in order to do which effectually,we must acquire more knowledge than has hitherto been obtained!"Medical science had undoubtedly made enormous strides of late,and culminated in the most stupendous discoveries;but still there remains the great task of lowering the frightful mortality of children under one year of age.It is strange how this has persisted,the more so as the death-rate of adult persons has notably diminished under the benign influence of well-known enactments. In short,the infantile death-rate is not declining,and so the nation's newborn strength continues to be sapped unchecked.The following table gives interesting information in this particular;it comprises the decennial death-rate of England and Wales,for adults and infants,and the birth-rate:

Years	Birth-rate per 1000	Death-rate per 1000	Infantile Mortality per 1000
1851 - 60	34.1	22.2	154
1861 - 70	35.2	22.5	154
1871 - 80	35.4	21.4	149
1881 - 90	32.5	19.1	142
1891 - 00	29.9	18.2	154
1901 - 05	28.4	16.0	138

It is a well-known fact that the birth-rate has also been decreasing;and the obvious interpretation of this is that it behoves the nation to take better care of its components of tender age,so that they may safely weather the morbific storms which assail them and grow up to be strong,healthy,and useful members of the community. I have noticed that the larger proportion of fatalities occurs during the first three months of life,which is admittedly the most critical period of the child's existance,though not a few,even after this period,show signs of profound constitutional taint.During the first year numbers of children contract disease solely owing to the carelessness or ignorance or indifference of the parents,exposure to cold and improper feeding being perhaps the principal faults,as evidenced by the great prevalence of diarrhoea,marasmus,rickets,bronchitis,etc., at this period.Though all these children do not die, many of them grow up to be weaklings and have their vitality endangered by the relics of infantile years.It is later on in life that rickets,antedating perhaps to the time of birth,especially manifests its signs,particularly as regards skelatal deformities and anomalies and dental lesions.Not a few of these children make show mental enfeeblement,and sometimes to such a degree that they are unable to take full advantage of the usual educational facilities.Therefore,the presence of rickets should be looked for from the very first,and all possible done to eradicate the dangerous taint.But the child alone should not be considered,for the pregnant woman requires some important supervision,as we shall in due course observe.The necessity for the management of the lactation period on approved scientific lines is very great,and the employment of these women in factories must always be debarred.The importance of fresh air must be insisted upon,and the virtues of cleanliness pointed out.The question of artificial feeding is a vital one,and comprises far-reaching principles,as will later on appear.

N O M E N C L A T U R E

Rickets has from time to time been accorded various synonyms, of which the following are the best known:
Rachitis; Rhachitis; Rachitismus; Morbus Anglicus; Articuli Duplicati; Chastre; Nouures des Jointures; Maladie Anglaise; Englische Krankheit; Zweiwuchs; Doppelte Gleider(Double-Jointed); Scrofula Rhachitis; Osteoporosis; Rachitisme.

E T Y M O L O G Y

It is supposed that the name "rickets" is an English modification of the old Norman word "riquets," which signifies a humpback. Some have traced the etymology of the disease farther back and state that it is a derivative of the old "wrickken" or "wrikken", which means to twist or wrest; anyhow, the affection was known in this country many hundreds of years ago. Indeed, so well acquainted were the laity with the marked deformities produced by the disease that the term "rickety" soon came into general use, and was, and is, used in referring to unsatisfactory everyday articles, such as rickety tables and chairs. Glisson, who first describedthe disease in the middle of the seventeenth century, suggested that the name should be changed to "rhachitis," partly, no doubt, from its resemblance in sound to rickets, and partly from the Greek "rachis", signifying the spine which it particularly, according to his experience, affects. The affection is said to have been unknown upon the continent prior to the publication of his observations, but it soon became known there under such designations as the "morbus anglicus", "maladie anglaise", and "englische krankheit," all of these terms denoting the country of its supposed origin. In Germany this "English disease" was called also "articuli duplicati," with a view to recalling the swellings at the ends of the long bones which are so characteristic of the disease, and give the patients an appearance of being double-jointed. "Chartre" is a French word of great antiquity, and seems to have had its origin in the Latin "castrum", meaning a prison, it being intended to convey the idea of the patients being imprisoned in a disease depriving them of the power of movement. In France it was also called "nouures des jointures", which is an expression derived from the similarity of the enlargements of the epiphyses to the swellings or knots sometimes seen in the branches or trunks of trees from obstruction, as well as the idea that the joints, or the limbs a little above, appear as if they had been bound round with a string - hence the word "noues" or

tied up.Some observers used the term "scrofula rachitis" to indicate that rickets is a variety of scrofula, Thomas Young and Evanson and Maunsell being advocates of this theory;others termed it "osteoporosis".Bouchut conjoined it with "osteomalacia"in agreement with Boyer and Beylard,who affirms that "rachitis and osteomalacia constitute one and the same disease of the bones,modified by the age of the subjects.I consider that rachitis is the osteomalacia of infancy".Whatever the derivation of rickets,it must be allowed that the word is a good one for general use,it being simple,distinctive,and easy to pronounce.

D E F I N I T I O N

Rickets is a general disease of malnutrition, occurring principally in children between the ages of six months and two years, characterised by the softening, and consequent bending and deformity, of the bones, with enlargement at their epiphyseal ends, gastric disturbances, weakness of muscles, relaxation of ligaments, retarded teething, and increased reflex excitability of the nervous system.

It should be particularly noted that the affection in its osseous manifestations is not of sudden onset; for prior to the development of its bony changes there is a period of invasion which is marked by gastrointestinal ailments, diarrhoea, nocturnal perspirations, weakness, and a certain amount of temperature rise. The digestive disorders are characterised by frequent vomiting, diarrhoea alternating with constipation, the stools being very acid and mixed with food particles that have failed to undergo digestion higher up. The perspiration is also acid, and it is profuse on the abdomen and on the scalp, so that during sleep the patient's head is soaked with liquid which leaves its mark upon the pillow. The first deformity to make its appearance is one about the wrists or ankles; it then attacks the condyles of the femurs. The anterior end of the ribs also undergo enlargement. Sometimes the malady is restricted to these epiphyseal enlargements, but in other cases the shafts of the bones are bent and bent in by the pull of the muscles or by the weight of the body or the pressure of the air. In the later stages of rickets deformity is sometimes caused through longitudinal growth of the bones by reason of eburnation of the epiphyses. When the spine and thorax are affected, great deformity of the trunk results from the antero-posterior and lateral curvature of the vertebral column, accompanied by flattening of the thorax and lateral deviation of the ribs; the pelvis also becomes deformed, and the cranium exhibits flattening of the occipital portion, together with prominence of the frontal centres of ossification, and an increase of the biparietal diameter, giving to the whole head a peculiar square and box-like appearance. The angles of the jaw sometimes exhibit excessive squareness and prominence, and there may be great vaulting of the roof of the mouth, with protusion of the narrowed jaws, consequent upon yielding of the softened bones during the act of suction on the part of the nursling. In a large number of the cases the affection is most conspicuous in the lower limbs. The skelatal changes affect the ankles and legs more than the thighs, and the lower portion of the body more than the upper, while the distal portions of the upper limbs suffer in preference to the upper portion of the skeleton and skull. There are, however, exceptions to this rule, one sometimes observing curvature of the vertebral column and deformity of the chest without any alterations in the lower limbs and pelvis. Cranial osseous anomalies are the outcome of delayed closure of the fontanelles, which, instead of disappearing at the end of the second year of life, sometimes are seen to be patent right up to the third or fourth year of the

of the child's age.The result of this is that the brain, continuing to grow,dilates the skull until its measurements are exaggerated out of all proportion to the size of the face.There is a certain resemblance between the form of the rachitic skull and that of the hydrocephalic skull,but the intellectual condition in the two affections is quite different.The hydrocephalic brain is imperfectly developed,and is overwhelmed by a dropsical effusion which interferes with the intellectual activity; but the rachitic brain,not being interfered with by compression,is free to grow,and its functions are unimpeded and perhaps uncommon.The intellectual activity and incisive wit of rachitic humpbacks have always been remarkable;and it was from this class that the court fools and jesters of the middle ages were drawn.The above-mentioned anomalies of the jaws has a peculiar effect upon dentition,great delay in the eruption of the temporary teeth being one of the early important signs of the disease.The narrowing of the jaws not infrequently leads to the teeth being crowded out of place,so that great irregularity in their position and order of appearance may be observed.The form of the teeth may be likewise altered,so that they appear too large and roughly constructed,and also changed in various ways presently to be described.The deformity of the chest is one of the best-known skeletal changes in this disease.The normal antero-posterior and lateral curves of the spinal column are sometimes greatly exaggerated,and the dorsal lateral curvature has its convexity always directed towards the right side of the body.A compensatory curve in the opposite direction is developed in the lumbar region.The spine is also twisted upon itself,so that the ribs project strongly upon the side of the lateral convexity of the spine,while there is a corresponding depression of the ribs upon the opposite side of the trunk. The posterior line of incurvation of the projecting ribs forms the prominent ridge of the humpback,and a corresponding projection of the costal cartilages and angularly curved ribs exists in front upon the opposite flattened side of the thorax.At the point of junction between the costal cartilages and the anterior extremities of the ribs an ossified protuberance can be felt beneath the skin upon each rib,distinctly marking the line of morbid proliferation and ossification in the sterno-costal epiphyses.The breast bone itself is often pushed forward and rendered prominent in a way that gives to the laterally compressed thorax a remote resemblance to the chest conformation of a bird:hence the term pigeon-breast that is often used to designate this skeletal change.The lower portion of the thoracic walls is often considerably everted in consequence of the compression of the lateral walls of the chest by the weight of the atmosphere;while the abdominal viscera, pressing upwards and outwards,expand the lower ribs, which rest upon the diaphragm. Excessive enlargement of the abdomen,consequent upon gaseous distension of the stomach and intestines,together with the downward displacement of the liver dependent upon the rachitic deformity,is not infrequently seen in this disease.Pressure gives rise also to various pelvic anomalies.The lateral walls of the pelvis are sometimes pressed inwards,causing anterior projection of the pubic symphysis;but in those cases in which there are lateral curvature of the spinal column and unequal distribution of

the weight of the body upon the sides of the pelvic bones,its walls are flattened upon the same side with the deviation of the lumbar spine,while a corresponding projection of the osseous structures at the inferior strait exists upon the opposite side.The chest deformity interferes with the lungs;they are of irregular dimensions and stunted in growth.The heart is not infrequently displaced upwards or to the right;and,owing to the fact that it is forcibly crowded against the front wall of the chest,its pulsations are unusually conspicuous,the difficulty attending its movements sometimes causing actual hypertrophy of its muscular tissue.These patients may suffer from emphysema,and disease of the respiratory organs is especially dangerous on account of the difficulties that attend the movement of the lungs and the pulmonary circulation of blood.Rickety children not infrequently exhibit the phenomena of spasmodic croup,laryngismus stridulus,spasm of the glottis, and exaggerated forms of pertussis - the same being due to the special tendency to spasmodic contraction of the laryngeal muscles.In the case of females pelvic deformity is especially dangerous,for it may occasion the person's death when the time for childbirth arrives; short of this,unusual difficulty in labour is to be feared.The rickety individual has a clumsy and laborious gait when there exists deformity of the long bones,giving rise to such anomalies as knock-knees,bow-legs,and club-foot.It may be also that the bones are so fragile that they readily fracture;the bones may fail to unite and so occasion other troubles.Even the foetus is liable to be affected,though exceptionally,with deformity of the long bones,or with multiple fractures,enlargement of the fontanelles,and other changes which constitute the so-called intrauterine rickets.It is also probable that in not a few instances the children of badly nourished and debilitated mothers show at birth the symptoms of congenital rickets,and during the period of pregnancy this fact must continually be remembered.Again,the oncipience of the disease may be delayed until the later years of the child's life,rickets being then observed as a sequel of perhaps one of the exanthemata, such as measles.Some refer also the lateral curvature of the vertebral column that is sometimes seen at the age of puberty to this disease.An acute form of rickets has also been described,which will receive consideration in due course.

HISTORY

Rickets differs from certain other affections in having its origination wrapped in obscurity, though much has been written upon the mooted point. Many writers affirm that the affection was unknown prior to the publication of Glisson's famous work in the seventeenth century, while others insist that it was known long before the advent of this observer. Indeed, so good an observer as Beylard mentions that it was known in the time of Hippocrates, who is said to have alluded to the affection in his description of certain deformities; while somewhat vague references to osseous anomalies occur in the works of Galen, Celsus, and Zacutus Lustianus. But more definite evidence of its recognition appears in the case described by John Baptist Theodosius, which was that of a child, aged seventeen months, suffering from curvature of the spine and ribs. Other writers affirm that in the sixteenth century rickets was not unknown in Germany, Switzerland, Holland, and France. Prior to the seventeenth century there is no definite description of the disease extant. Trousseau (Clin. Med., Vol. v, p. 47) tells us that "in the year 1630 the English mortuary tables make mention, for the first time, of a disease, which the oldest inhabitants and the oldest practitioners did not remember to have seen prior to that date. It was called by non-professional persons 'the rickets'". Soon after this several cases appeared in the literature, and a number of medical practitioners, who had proper opportunities for studying this new disease, had a meeting and made an interesting report on the disease. Three of their number, Glisson, Bate, and Regemorter, were appointed to deal with the question; and this culminated in the first-mentioned observer writing a full account of rickets. His well-known and oft-cited publication was entitled "De Rachitide, sive Morbo Puerili", was written in Latin, and first saw the light in 1647. The edition being soon sold out, another one appeared three years later, and yet a third in 1671. His account of the disease was remarkable for its clearness and comprehensiveness, no point of importance, to his mind, being overlooked. For instance, he showed that rickets had undoubtedly been observed at birth, but that it usually began after the first six months of life, and that it was occasionally endemic in certain parts of this country. He noted that teething was delayed, and that, if the teeth had been cut before the onset of the disease, they very soon decayed. The interference with the respiration of the child, leading to insufficiency of the circulation and enlargement of the veins under the skin, especially those of the scalp, was mentioned in his report; and also the "pot-belly" which he considered as being due to the fact that rickety children were unusually large eaters. He referred rickets to disturbed nutrition by arterial blood, and held that the changes in the osseous structures were due to their excessive vascularity - this point being of special interest in view of Kassowitz's experiments, in which he produced hyperaemia of the bones artificially with resulting changes not unlike those observed in rickets.

In view of Glisson's memorable and epoch-making observations, some account of his life may not be out of place. We read that he was born in the Dorsetshire village of Rampisham in 1597, and that he finished his education at Caius College, Cambridge, of which he ultimately became a Fellow. He graduated in physic, and replaced Winterton in the chair of that subject in the university - a position which he held with distinction for forty years. In 1634 the London College of Physicians elected him to their fellowship; and in his professional methods he followed in the footsteps of the great Harvey and depended more upon practical anatomy and minute investigations than haphazard theories and more or less impossible hypotheses. During the civil wars he started practice in Colchester, and did excellent work during the siege and surrender of the place. He was soon placed in a position far above his contemporaries through the great attention which he paid to the evolution of rickets, an affection which first commenced to appear in Dorset and Somerset - these observations being, in 1654, published under the title of "Anatomia Hepatis". He was for several years president of the College of Physicians, was one of the original members of the Royal Society, and died in 1677, in the London parish of St. Bride's. His biographer (Lempriere, - Universal Biography, 1808) tells us that he was a very learned man, that he had no enemies, and that everyone respected him. Lempriere, referring to his colleague, George Bate, says that he latter was born at Maids-Morton, near Buckingham, and that he was educated at New College, Queen's, and St. Edmund's Hall, Oxford, practising as a physician in the University. He He was so clever and tactful that he became physician to Charles I. while at Oxford, and afterwards to Oliver Cromwell, and to the Court after the Restoration. His recommendation to Charles II. originated, we are informed, in the report that he had given Cromwell as dose of medicine which hastened his death. He was a prolific writer on both medical and historical subjects; he died in 1699, and was interred at Kingston. According to Cumin Cyc. Med., v, 48), there is considerable doubt as to the alleged origination of the affection in the seventeenth century, though it is a matter of surprise that a disease with such striking characteristics and "infinity of varieties" should have been overlooked until so late a period. Moreover, it is "inconsistent with several terms in the Greek and Latin languages denoting deformity and decrepitude of the human frame, and with instances given in the ancient history of persons so afflicted, who were distinguished in various departments of letters, and even in arms. Van Swieten (Clin. Med., v, p. 48) held that rickets was undoubtedly a new disease, though in his time and since the point has been a subject of interminable controversy. Beylard (On Rickets, Fragility of Bone, and Osteomalacia, Paris, 1852) contended that, far from being a new disease in Glisson's day, it was known to such ancients as Hippocrates and Galen; and he quotes the German observer, Whistler, as a writer on the subject prior to Glisson's time. Whistler's work (Diss. Inaug. de Morbo Puerili Anglorum dicto The Rickets, Leyden, 1645) is now almost priceless; and I understand that a copy of it can be consulted in the Oxford Bodleian library. The very title of the publication proves that rickets was well-known in this country as a children's disease, and

that it must have been in existence for a long time in order to have received the nickname it now bears(rickets). It would seem,then,that Whistler was well acquainted with Glisson's report,and that the observations of medical men in this country were really anterior to those of Whistler,in spite of the fact that the latter's publication is dated two years previous to the alleged date of the first edition of the well-known treatise on rickets.Norman Moore(Trans.Path.Soc.,1881,xxx)says that Whistler does not deserve to be regarded as the discoverer of rickets,especially as the only claim which can be urged in favour of it is his 1645 thesis entitled "Paedosplanchnosteocace",of which there is no trace;and, moreover,his own affirmation carries little weight,as he appropriated the funds of the College of Physicians during the time of his presidency.The softening of the bones in rickets was described by Mayo,of Oxford,in 1660;and in the eighteenth century there were numerous important observations on the disease as affecting both man and animals.Thus,in 1707,Bicherod(Act.Maris Balthici)noticed softening of the bones in the case of the ox,and Lordat studied the affection in the case of the monkey.Dupuy(De l'Affection Tuberculeuse)investigated the osseous conditions in the case of the horse which was rickety,and Mason Good(Study of Med.,v,327)tells of the occurrence of rickets in the lion,an observation which has since been confirmed by Bland Sutton in the London Zoological Gardens.The Bishop of Cork(Philosophical Transact.,1740,1741)tells of the case of a man who suffered so severely from rickets,as a child,that every bone in his body was deformed and distorted."At the age of eighteen he began to grow stiff,and at length,having lost all use of his limbs,he became like a statue; he survived until his sixty-first year,and at his death his skeleton was found to be one continuous bone from the top of his head to his knees.Many osseous growths,some of them of the most grotesque forms,branched from his head,back,and haunches;and a portion of fully-formed bone was also found embedded within one of the large muscles."Petit,in 1741,wrote very seriously regarding the evil effects of early weaning;and in 1751 Duverney investigated the pathology of rickets and pointed out the fragility and rarefaction of the bones,as well as their liability to fracture under comparatively trivial traumatic conditions.In 1772,Comber(Letter on Rickets in Sheep)described rickets as it occurs in sheep.Twenty-five years later,Portal classified rickety phenomena as syphilitic,scrofulous,scorbutic,rheumatic,and intestinal or exanthematous.The nineteenth century saw still greater progress in the knowledge of the disease.In 1817 Romberg(De Rachitide Congenit.)described the congenital disease),which,nine years later,received the attention of Sartorius(Rhachit.Congenit.Observ.).Lepelletier(Malad. Scrofuleuse,Paris,1830),in 1830,reported the finding of rickets at birth,and Henckel and Klein had similar observations.Bordenhave and Pinel described the affection in the foetus,the latter(Fourcroy's Jour.,La Med.Eclairée par les Sciences Phys.i,3)mentioning it in an unborn child of eight months.Rufz(Recherches sur le Rachitisme chez les Enfants,Gaz.Méd.de Paris,1834),in 1834,gave a good descrption of the disease as he observed it in numerous cases;and in the same year Jules Guérin gave the well-known classification of rickets in the following

stages:First,period of incubation or of effusion,in which there is a general distribution of the blood throughout the bones of the body;second,period of deformity,in which the spongoid tissue forms in the epiphyses,diaphyses,and the subperiosteal spaces,and in which the bones soften and bend;third,a period of resorption, consolidation,and eburnation,in which the spongoid tissue becomes compact and the bones very hard;and,fourth, a period of consumption(not constantly present)in which the osseous tissue remains fragile and rarified.The red reticulated tissue of the rickety bone was first called by him"spongoid";and it would appear that he tried the experiment of making animals rachitic by altering their diet,with success in the case of puppies.Further progres in the disease was made,in 1843,by Elsaesser(Der Weiche Hinterhopf.Ein Beit.z.Phys.u.Path.der Ersten Kinderh.,etc.,Stutt.u.Tubing.,1843),who investigated the striking change occasioned by rickets in the case of the skull,which same he called "craniotabes".In 1849Trousseau (loc.cit.)and Lasegue(Arch.Méd.,1849),and others dwelt on the resemblance of rickets to osteomalacia;and,in 1852,Broca(Soc.Anat.de Paris,1852)gave a precise description of the microscopical alterations of the disease in the case of the bones,mentioning that it is due to an arrest or suspension of normal bone development.In the following year Virchow(Arch.f.Path.Anat.,1853,v,S.409-507)drew attention to the analogy of the rachitic osseous changes to parenchymatous osteitis;and later on Kassowitz and Baginsky lent their support to this theory. In 1881 Parrot(Internat.Med.Congr.,Lond.,1881)vaunted the hypothesis that rickets is,in both the anatomical and the clinical sense,always an outcome of syphilis.This theory,we shall presently see,was effectively disposed of by various authors.In 1895 Sir William Jenner gave important lectures on rickets,which are amongst the classics in the literature of the disease.Sir.William Barlow conducted far-reaching investigations into craniotabes and scurvy;and another great authority,Cheadle, is justly honoured for lending the weight of his opinion to the theory that rickets is a food disease largely due to a shortage in fatty material.Bland Sutton's experiments are of great importance too.

PATHOLOGICAL ANATOMY

THE BONES

Nature of the Lesions.

The principal pathological condition dominating the morbific picture in rickets may be summed up in the aphorism that it is "an exaggerated preparation for ossification and a diminished accomplishment of it". Though the obvious and well-recognised lesions of the disease occur in the osseous system, it must be noted that the various organs of the body do not invariably escape, though from the absence of very definite symptoms it is sometimes supposed that they do. In rickets we find hyperplasia at the epiphyses, periosteal thickening, a deficiency of lime-salt deposition, a soft and gelatinous medullary tissue, and a softening of the skeletal system generally. In time the bones become bent and deformed, and it is quite common to encounter greenstick and other fractures. But, sooner or later, signs of resolution are observed, the bones becoming undergoing hardening and eburnation and ultimately harder than under normal conditions. These individuals sometimes grow up to be dwarfs, and in adult life, without incapacitating disease, exhibit their childhood rickets in the shape of such anomalies as thickening of the articulations and alterations in the normal appearance of the head.

Physiological Considerations.

Physiology teaches us that the long bones lengthen by the development of osseous tissue between the shaft and epiphyses; that they become thicker by bone formation under the periosteum; and that the absorption of the inner bony layers is responsible for the production of the medullary canal. Now, in rickets we find an interference with this order of things. Thus, there is an excessive epiphyseal cartilage production, the periosteal deposition is increased, there is exaggeration of the absorption of bone for normal medullary construction, so that the medullary canal is large and full of spongy material. Further, calcification is imperfectly performed. Prior to the production of ordinary bones, there is, in the case of the long ones, active growth in the diaphyseal cartilage, chondroid and spongoid stages being therein observed. The tissue in question is a layer of hyaline cartilage separating the body of the bone from the head. It enlarges and undergoes proliferation, with the result that a spongy layer is formed, which presents a network of trabeculae. The chondroid layer, which measures from a half to two millimetres, lies between the diaphyses and the intermediate cartilage; and it is composed of primary cartilaginous capsules, in which are contained secondary capsules interspersed amidst the layers of granules or rivulations of Broca. The first deposition of lime salts occurs in these rivulations; it is next seen in the primary capsules, and lastly in the secondary ones after their disintegration. The result of this is that there is a mingling of substance with the primary capsules, with absorption of the calcified separations and production of the spongoid layer of Guérin. This proliferated and ossified cartilaginous tissue is

invaded by blood-vessels, from the peripheral trunks, which form for themselves canaliculi in the usual way.

Pathogenesis in Rickets.

The normal processes of bone formation are perverted in rickets, the disease affecting the osseous system in the following ways: First, it interferes with their growth, not only temporarily, but often permanently; it interferes with their development, perverting the process of ossification, and rendering the calcareous deposition irregular and incomplete; and, thirdly, it produces serious changes in the bones already ossified -i.e., the osseous tissue loses in density, weight and firmness, so that the bones yield under the pressure of the fingers and can be cut with a knife much after the same fashion as a carrot or a soft piece of wood. Jenner (Med. Times & Gaz., March 17, 1860, p. 261), describing the osseous changes of rickets, says that "there is an exaggeration of the conditions we find in the first stages of ossification in the healthy subject; the completion of the process only is stayed", -that is to say, great preparations are made for the process of ossification, but the performance of that process is extremely irregular and insufficient for the purpose in view. The alterations which rickets produces in the bones were well known to such of the earlier writers as Boyer (Treatise on Surgical Diseases, iii, 619), who gives a good account of the appearance of a rickety long bones. "They are", he observes, "lighter than natural, and of a red-brown colour; they are penetrated by many enlarged blood-vessels, being porous, soft, spongy, and compressible; they are moistened by a kind of sanies, which may be pressed out of their structure as out of a sponge or tanned leather; the walls of the medullary cylinder of the large bones of the extremities are thin, while the bones of the skull are considerably increased in thickness, and become spongy and reticular. All the affected bones, especially the long ones, acquire a remarkable suppleness; but if they are bent beyond a certain point, they break. Instead of being filled with medulla, the medullary cavity of the long bones contains only a reddish serum, totally devoid of the fat, oily nature of the natural secretion". In a healthy infant at the age of four or five months, the shafts of the long bones are completely ossified, while the epiphyses still consist of cartilage. As we have already seen, the bones increase in length by ossification between the epiphyses and the shaft, and in thickness by the deposition of compact bone underneath the periosteum. The bones of the skull, except at their edges, where there remain the spaces known as fontanelles. The use of the microscope brings out well the alterations of the bones in this disease, there being noted a production of defective material, too much activity of the cartilage cells, and in the place of normal calcification an excessive vascularity with the formation of large spaces filled with a jelly-like substance. Mere inspection shows that there is thickening of the epiphyses of the long bones, with a preferential location of the lesion in the radius and ulna. It is not difficult to bend these bones. Guérin's four stages have been referred to above. The first one is that of incubation or effusion, and in it the chondroid layer, normally measuring from a half to two millimetres in thickness, becomes from four to twelve, swollen and sponge-like, and of a bluish aspect. There is an irregular and indented

margin on the side opposite to which it blends with the cartilage. Cartilaginous proliferation is excessive, with a confused mingling of spongoid and chrondroid material. There are therefore islands of cartilage in the places where there should be bone. Instead of dissolving, the secondary capsules undergo calcification. there is free vascularisation, and the interspaces contain gelatinous marrow instead of normal osseous material. The osseous trabeculae undergo erosion in this spongy layer, so that connective tissue and blood-vessels appropriate the large medullary spaces. The latter are continuous with the channels of the shaft of the bone, so that we have the ultimate formation of a spongy and vascular tissue, and also an abundant presence of a reddish substance not unlike gooseberry jelly in appearance. Similar alterations are seen in the periosteum, there being a faulty ossification with an excessive proliferation of material; the outer layer of the membrane is very thick and vascular and adherent to the roughened bone; the inner bone-forming layer is in great activity, connective tissue being formed at first in preference to bony material. There is marked thickening of the subperiosteal osseous tissue, but the bone so formed is of an inferior kind, being spongy and exhibiting a shortage of lime salts. These periosteal changes are more conspicuous on the concavity of the bone. The bones thus affected are more dry than normal, very spongy, and imperfectly calcified. They are easily bent, and yield to the muscles attached to them. In Guèrin's second stage, that of deformity the bones are markedly spongy and biscuit-like there is absorption of the lime salts and also a replacement of the same by fibrous tissue. In his third stage, that of resorption or consolidation or eburnation, the excessive vascularity is diminished and ossification proceeds in the usual way, with the ultimate result that there is formed a very dense osseous tissue which may become as hard as ivory. His fourth stage, that of consumption, is, as stated, not always present; and in it consolidation of the tissue does not occur, the bones becoming fragile, light, and composed of a fatty areolar material. Sometimes the deformities produced by these changes undergo diminution; but not always, as they may last through life and convert the individual into a humpback or dwarf. Long ago Trousseau (loc.cit.) drew attention to the lightness of the rickety bones, there being a comparative lightness even after the occurrence of consolidation, and the bones weighing perhaps only a seventh of the normal. Jenner noted that such bones were soft and easily bent, that they were readily sliced with the knife, very liable to become broken under trivial traumatic conditions, deficient in earthy salts, and productive of less gelatine on boiling.

Composition of Rickety Bones.

The normal proportion of two-thirds inorganic material to one-third organic is changed in rickets to one-third of the former to two-thirds of the latter; the absorption of phosphate of lime would appear to be responsible for this. In ordinary bone there is, to be accurate, sixty-three parts inorganic to thirty-seven parts organic material; but in rickets seventy-nine of the former to twenty-one of the latter; and the shortage of lime Kassowitz, whose authoritiative opinion must always command attention, refers to deficiency of deposition, and not to absorption.

THE SKULL.

In such flat bones as those of the skull the changes of perverted ossification are to be seen, there being delay in the normal processes, atrophy, and hyperplasia of components. The delay in ossification is noticeable especially in the occipito-parietal region, in which locality ossification may be replaced by a membranous formation. When there occurs an atrophy of previously formed bone we find that the part yields to finger pressure like parchment; and, on removal of the dura mater, small, pit-like depressions may be found on the inner table. When hyperplasia occurs we have the formation of hyperostoses or cranial bosses. These elevations are formed principally from the outer table, and consist of red, vascular, spongy material which finger pressure causes readily to yield. Elsasser was the first to draw attention to the thinning of the inner cranial table, and he coined the word "craniotabes" to indicate it. These patches have been ascribed to enlargement of the brain pressing on the vault, and also to pressure of the head on the pillow; but it is more likely that they are due to imperfect ossification of the bones. The cranial bosses are sometimes absorbed, but may become diffuse and cause a general thickening of the skull; but more often they persist and give the characteristic appearance of the rickety forehead. Sir Charles Bell's private collection is said to have contained rickety parietal bones which, at their centres were seven-eighths of an inch in thickness. The cranial bosses, resulting from a thickening of the bone above the ossification centre, are generally located on the frontal bone's outer table, and are soft, spongy, and very vascular. The great increase of the trabeculae is obvious on section; they are seen to be composed of spongy masses, and under finger pressure give exit to blood and serum. They remain usually throughout life, though in rare instances they may be completely absorbed and leave no relics of their infantile existence. The rickety cranium has its forehead square, broad or prominent; and on either side the bosses or thickenings are to be observed. The head is square or oblong, and the vault of the cranium is flattened, with well-marked occipital and parietal eminences. There is a well-defined groove between the two halves of the frontal bone; this is continued backwards to the anterior fontanelle, - which remains open for two or three or even five or six years, instead of closing at from the eighteenth to the twentieth month, - and then between the parietal bones to the occiput. Another distinct groove may be detected in the temporal region, and between the sutures elsewhere. These grooves are due to the membranous condition of the cranial bones and the operations of the subjacent venous trunks. The entire cranium may be so soft that it can readily be crushed with the fingers; it is considerably larger than normal, and it may even be greater in circumference than the chest. In contradistinction to the hydrocephalic head, which is almost circular in outline, the rickety skull, as we have seen, is oblong. There is sometimes a marked asymmetry of the cranium, one side of the frontal or occipital region being considerably larger than the other. The face, when compared with the large skull, seems small; the upper jaw tends to become beak-like and the lower one squared, with some inversion of the anterior surface. The base of the skull is not

usually involved,though sometimes it is found to be in a state of softening.The enlarged and prominent veins are very noticeable over the scalp,and pale-blue swellings indicate the presence of the above-mentioned bosses.

The Teeth.

The teeth of rachitic children fail to make their appearance at the usual time,and even at the age of twelve months toothless gums may be observed.Further, they not infrequently cut the gums in irregular order. They are usually of defective construction,fragile and deficient in enamel.They decay early and are soon observed to fall out.The permanent teeth also suffer,as we shall presently see.

THE THORAX.

The chest of the rachitic patient,especially if the subject of bronchitis,is markedly altered in appearance.At the junctions of the ribs with their cartilages there are enlargements,constituting the so-called "rickety rosary".These nodules or beads may be present at birth,or even in the foetus,are frequently very conspicuous in the lower ribs,especially on their inner surface.This beaded condition never persists to adolescence,but is one of the early signs by means of which the existence of the dyscrasia can be inferred.The angles of the ribs are also bent or kinked.The shape of the chest is modified by the softening of the ribs and their consequent yielding to both atmospheric and mechanical pressure.There is a large conspicuous groove, known as Harrison's sulcus,which runs on either side of the chest from the lower end of the sternum across the chest to the posterior border of the axilla,just above the line of attachment of the diaphragm.Some affirm that it is due to the softened ribs yielding at their point of least support;whereas others insist that it does not correspond to the attachment of the diaphragm, but follows the upper limits of the stomach,liver and spleen,and also that it is not infrequently asymmetrical.Another groove runs vertically down the front of the chest,internal to the junction of the ribs with their cartilages;and it is just outside this depression that the rickety rosary is to be seen.These depressions cause a prominence of the sternum,which is more marked when there has been any respiratory obstruction,such as bronchitis,pertussis or pharyngeal adenoid growths.The altered shape of the chest causes alteration in the position of the apex of the heart,giving rise to a white patch,due to friction,on the front of the left ventricle,instead of the right ventricular normal condition. Partial or greenstick fracture is usually responsible for the swellings at the angles of the ribs behind.As stated,the beadings are more marked on the inner than the outer aspect of the ribs;the latter can be easily bent or kinked.The periosteum is thickened;and when the bone is broken,the two ends are held together by a superabundance of connective tissue.A longitudinal section through the chondral end of such a rib shows that the beading mainly involves the columnar zone of the cartilage,and that the epiphyseal line which separates bone from cartilage is more irregular and wider than normal.A cross section will demonstrate that compact tissue is almost entirely absent,and that the bone is composed of a soft,spongy and gelatinous tissue tinged with red.The collar bones are thickened and twisted,

and sometimes the shoulder blades are similarly affected.

THE SPINE.

Relaxation of the weakened muscles and the general debilitation of the part cause the patient's back to be rounded, with the production of the characteristic rachitic kyphosis or humpback. This rounding is not the angular gibbosity due to spinal caries, but a more or less regular convexity of the vertebral column backwards. There is sometimes a slight lateral curvature, and the forward lumbar curve is more pronounced. In mild cases the vertebrae are usually not markedly affected; but, on section in a severe case, we observe a proliferating zone of bluish colour between the body and the disc, the former structure being abnormally vascular, spongy and soft. In most of my cases the curvature has been in the mid-dorsal region, the direction of the curve being more often to the left than the right side.

THE PELVIS.

The possibility of future pregnancy in the case of the female makes the pelvic deformities of rickets of prime importance to the sex. The rickety pelvis in childhood is rather triangular than oval; but the shape is modified by the age of the child, i.e., the shape varies with the position of the patient whilst lying down, crawling or walking. The pelvic bones are softened as are other bones, with the result that it responds to mechanical forces acting upon it. Thus, the weight of the body above on the pelvis is resisted by the lower extremities, the pelvic bones are acted upon by the muscles attached to them, and the imperfect ossification has well-known effects. The most typical rachitic condition in this locality is a flat pelvis with contraction of its diameters, especially the antero-posterior. We may also find a simple flat pelvis with normal transverse diameters, or the so-called pseudo-osteomalacic pelvis, in which there is a uniform narrowing from mechanical pressure upon the softened bones. In the common form of rachitic pelvis, the fat or generally contracted, there is forward and downward displacement of the sacrum between the iliac bones, with rotation on its transverse axis from the pressure of the body and the downward pull of the psoas muscles upon the vertebral column and the upward pull of the spinal erectors on its posterior aspect. The tip of the sacrum and coccyx is thrown backwards and the bone itself lies in a more horizontal position than normal. The sacrum is also bent, owing to the resistance of the sacrosciatic ligaments and muscles. The iliac bones are more prominent than ordinarily. The innominate bones are abnormally curved, so that the transverse diameter is relatively increased; but as the whole pelvis is usually undersized, this diameter rarely exceeds or equals the normal transverse one. The bending of the innominate bones also throws the acetabula forward, so that the counterpressure of the lower limbs acts more anteroposteriorly than in the normal pelvis. The pubic rami and symphysis are diminished in height and do not slant outwards so much as normally. The cartilage here is enlarged. The inlet is shaped like the figure of 8. The ischial tuberosities are enlarged and pulled outwards and forwards, with widening of the arch of the pubis and increase of the pelvic outlet in diameter transversely. There is a general tilting of the pelvis forwards. The pelvic

bones are smaller and more brittle than normal, though sometimes they are thicker and heavier. The type of pelvis in which there is a general equal narrowing is due to arrested development in early life, and is a rare condition as is also the pseudo-osteomalacic one; their effects on labour are serious indeed.

THE LONG BONES.

Prior to Glisson's time the pathology of rickets was not understood, and all sorts of fanciful theories were in vogue concerning it; he was one of the first to note scientifically the softening of the bones and the culmination of this in consolidation. Duverney, in 1751, in his work on "Diseases of the Bones", mentions certain osseous changes due to rickets, such as rarefaction, lightness, and roughness of their surfaces from the presence of layers of osseous material formed by the "extravasation of the nutritive juices". Such observers as Storch regarded the changes as due to a disturbance of the growth of bones and muscles due to unequal distribution of the juices which feed the body; whereas others, such as Portal, regarded rickets as an expression of various morbid affections, such as syphilis, scrofula, scurvy and arthritis, most of them adhering to the scrofulous or syphilitic theories. Amongst the most important of the earlier researches were those of Rufz (Researches on Rachitis in Infants, Paris, 1834) and Jules Guérin (Memoirs on the General Characteristics of Rachitis, Gaz. Méd. de Paris, 1839). Guérin's observations are classical, and may here be considered in detail. He recognised four periods as follows: (1) Stage of Incubation or Effusion.- This period is marked by an effusion into all the interstices of the osseous system, which seem as if filled with blood less viscid and less consistent than that contained in the vessels. (2) Stage of Deformity.- This is characterised by the development of a very fine spongy tissue in the epiphyses and interstices of the long bones, and also between the periosteum of the bones, which later become soft and bent. (3) Stage of Absorption and Consolidation or Eburnation.- In this there is a transformation of the spongy tissue into a compact tissue denser and closer than the normal, a transformation which gives to the bone an extraordinary degree of solidity, converting it into an ivory-like substance. (4) Stage of Consumption.- This period is comparatively uncommon, and is observed in those who have long suffered from the disease, and in whom the so-called rachitic cachexia has developed. Guérin tells us that in this stage there is "no attempt at restitution. The bone remains modified; the matter effused into the areolae, and into the interlamellar spaces beneath the periosteum and the medullary membrane, is not transformed into that cartilaginous tissue which ought itself to be transformed into new osseous tissue. The old osseous tissue is generally absorbed". He also remarks that in "the recent state the long bones are very soft and friable. They are reduced to a very thin shell filled with fatty matter; in some places they are whitish, or of a more or less red hue, and contain the débris of osseous plates. In the dry state these bones are extraordinarily light, friable and brittle. The lightness and friability are not less remarkable in the short than in the flat bones, the tables of which become very porous, whilst their diploe, the cellules of which enlarge, assumes an aspect like a paste that has risen, and looks like a macaroon". The first stage, according to him, lasts for some months, when gastro-

intestinal irritation,night-sweats,mental depression and nervous irritability,as well as weakness of the muscles and ligaments,are prominent symptoms.Then become apparent the curvature and retarded growth of the bones.He holds that the deformity commences in the tibia and fibula and proceeds upwards.Of four hundred and ninety-six cases recorded by him,there were only eleven in which there was no curvature of the bones,although the general symptoms were present;in all the others the lower limbs were deformed.Of these four hundred and eighty-five cases there were affected with deformities fourteen in the upper extremity,forty-eight in the spine,fifty-nine in the thorax,and seventeen in the cranium.The "Lancet"of 1848(Vol.i,p.388)gives his comparison of the lengths of the bones of twelve healthy individuals with those of twelve cases suffering from rickets.In the case of the fibula the difference was three inches 9 lines;and in the case of the other bones the figures were - tibia,3.5;femur,3.1;radius,1.8;ulna,1.9; humerus,1.7;clavicles,0.6;sternum,0.5;spine,1.1;three pelvic diameters,1.9.The retardation of growth in the lower extremities is,from Guérin's results much greater than in the upper extremities;but other observers have given different findings.The reason for this discrepancy appears to be the time of the onset of rickets,whether before or after the art of walking has been acquired by the child.The periosteum of a rickety bone is more vascular than it should be,and the outer fibrous layer, as well as the inner proliferating one,is thickened. Macroscopically it presents a bright pinkish colour from the hypervascularity existing.The periosteum is easily stripped from the bone,which is also very vascular,and not possessed of the smoothness of health,but roughened from irregular osteoid deposits from the internal layer of this membrane.Inspection of a longitudinal section of a rickety long bone exhibits a large zone with a bluish semitransparent tint between the epiphysis and the diaphysis.Normally a thin,straight,transverse line,it is here much wider and of irregular outline.The yellow zone of cartilaginous calcification is even more irregular, and isolated pieces appear in the blue zone.Blood-vessels may be seen entering the cartilage at different levels,and the blue or proliferating zone is seen to be very much swollen.The shaft appears to be composed of very soft spongy bone,containing a large quantity of a gelatinous material of a reddish-brown tint.In the stage of resolution there is a deposition of healthy osseous material,the blood-vessels become involuted,and bone is developed around the former blood spaces in lamellar systems,with small or obliterated canaliculi,giving rise to the eburnated appearance of the bones so often seen in rachitic individuals.Our author remarks that the deposition of bone is most actively carried on in those parts where it is most needed,i.e.,"on the inner or concave surface of the curve";and the "thickness of the bone at the part most curved bears an exact ratio to the degree of curvature that the bone has undergone."But the deposition of osseous material is not,however,always "adjusted to the mechanical conditions of the parts of the body as means to ends,as witness the thickening of the cranial bones far beyond their normal extent and requirements".Development of bone occurs either by the intracartilaginous or the intramembranous method.The

former is observed in the case of the flat bones of the skull and face, and also in periosteal ossification. The long bones grow in length by the production of bone in the cartilage between the epiphysis and the shaft; and the shaft grows in thickness by production of osseous material beneath the inner layer of the periosteum; the medullary canal is continually increasing in size by the absorption of the inner layers of bone. In health also the growth in length is more rapid than the increase in diameter, and so in rickets the most conspicuous changes are present at the ends of the long bones. When a section of a long bone like the femur is made in its long axis, the prominent condition observed is the large size of the piece of cartilage which lies between the ossifice centres of the epiphysis and the shaft. It has also the appearance of undue activity. It has a larger number of absorption spaces than in health; and their blood supply is greater than ordinarily. The epiphyseal line is also much broader than in ordinary bone. The osteoblasts are more abundant, and they arrange themselves around the absorption spaces in the cartilage as in normal ossification. They go so far, then, as to provide the fibrous homogeneous matrix; but here the process ceases, and the precipitation of calcareous salts into the fibrous matrix; and thus the formation of true bone is arrested - a true arrest of development, or, as Jenner puts it, there "is extensive preparation for ossification and imperfect performance of the process". The bone therefore does not grow in length; hence the stunted appearance of the rickety individual. The crude fibrous tissue then accumulates at the epiphyseal line and causes the tuberose swellings which are so characteristic of the disease. In the same way the deep layer of the periosteum shows undue activity and cell proliferation. The fibrous tissue is laid down in successive laminae, but calcification is entirely arrested. The result of these changes is the undue flexibility seen in rickety bones. All the long bones are not affected to the same degree. Sometimes those of the lower extremities are most involved, sometimes those of the forearms, and sometimes the ribs. Various things are responsible for the osseous deformities. There may be exaggeration of the normal curves, and exaggeration thereof by the swelling of the epiphyses; again, muscular action, atmospheric pressure, posture, etc., can operate in their production, and deficiency of lime salts contributes to their pliability. Virchow (Virchow's Arch., 1853, No. 13, p. 430) drew attention to the fact that, in the beading of the ribs, the cartilage fits into the bone like the acorn into its capsule or cupula. There is interruption of the union of the flat bones of the cranium, which fail to unite and leave the fontanelles patent. Large bosses or prominences, due to thickening of the bone, usually make their appearance about the centres of ossification; they are soft and spongy, some mostly from the outer table, and are seen to be of excessive vascularity. Greenstick fractures may occur in connection with such bones as the radius, ulna, clavicle and ribs. This culminates in more or less impaction, and the condition is usually followed by a considerable callus or an appearance like a false joint. In from three to fifteen months there is a vigorous initiation of the stage of restitution, both in the cartilage and in the periosteum. The new periosteal bone is thrown down beneath the periosteum;

this deposit is most abundant on the cancave side of the bone and is very dense and ivory-like.So it came to pass that not infrequently the rachitic osseous changes terminate by the time that the child is about two years of age.In this stage the swellings at the ends of the long bones gradually diminish;and the curvatures sometimes also vanish,although not infrequently the bones of the legs show permanent deformity.In the case of the flat bones the bosses disappear and beading is not longer seen in connection with the ribs.To this order of events Guérin adds a stage of consumption,which by no means invariably occurs.If we make a longitudinal section through the beaded end of a rickety rib we find irregular proliferation and calcification of cartilage,as well as irregular formation of osseous tissue,with increased absorption of this osteoid material.The swollen end corresponds to the lower zone of the cartilage,in which the cartilage cells have undergone proliferation and are arranged in rows.Then comes the epiphyseal layer, normally narrow and sharply defined,which is here irregular and ill-defined,composed of areas of uncalcified cartilage,patches of calcified cartilage and osteoid tissue,with large medullary spaces and blood-vessels. The bony part consists of cancellous tissue with large spaces.There is a richly cellular marrow,but a scarcity of fat cells.In short,the bone shows scarcely any of the characteristic features of normal tissue.Lying in the recesses of the osteoid tissue may be seen large cells with two or three nuclei;they are called the osteoblasts and assist the blood-vessels in the production of true bone.Beneath the periosteum,which is thicker and more vascular than normal,there is an excessive cell formation;but calcification is retarded and the result is a spongy appearance of the part.The increased vascularisation of the tissue in which the bone is to be formed, the marked hyperplasia,and the increased osteoporosis of both compact and spongy bone are well seen on microscopical examination.Ashby(Ency.Med.,x,457)describes the changes which occur in rickets,and remarks that "it is interesting to compare the changes noted in the bones of young animals fed on foods poor in lime salts, and in which a sort of pseudo-rickets takes place. Stoeltzner(Stoeltzner und Salge,- Beitr.z.Path.des Knochenwachs.)fed a six-weeks'-old puppy on raw horse flesh,bacon,and distilled water,a food poor in lime salts.The animal gained in size and weight during the research,which lasted eight weeks.Ten days after the commencement of the experiment the bones appeared to be tender,there was some swelling of the epiphyses,beading of ribs,and bending of the long bones of the limbs.On examination of the bones at the section showed swelling of the ends of the ribs corresponding to the columnar zone of the cartilage,some thickening of the periosteum, and a high degree of osteoporosis that at first sight appeared incidental with rickets.A careful examination showed that this osteoporosis differed essentially from rickets,in that in rickets an excessive preparation for ossification took place,viz.,a rich formation of osteoid tissue which,however,remained almost uncalcified,while in osteoporosis but slight preparation,much less than normal,took place,and in spite of the scarcity of lime salts this little was calcified.Also in osteoporosis,in opposition to rickets,the cartilage matrix,

in spite of the insufficiency of lime salts, became calcified. It will be seen that the chemistry of rickets is notably different from that of health when the bones contain one-third organic and two-thirds inorganic matter, whereas in a well-marked case of rickets the proportion is reversed, the bones not infrequently consisting of three times as much organic as inorganic material. The bones, if examined when the disease is at its height, will be found to be remarkably light. The water and organic matter in them is increased, as likewise the fat (Hamilton,- Manual of Pathology, Vol.ii, Pt.2, p.834). There have been various theories advanced to account for this, such as a faulty secretive activity of the osteoblasts, a deficiency of the earthy salts of the foods more especially the phosphates, and a failure of the digestive tract to absorb the essential salts. Hamilton (loc.cit.) thinks that the first theory is the more feasible and that the osteoblasts may revert to the fibroblastic form. Wachsmuth (Jahr.f.Kinderh., Bd.39, H.1, S.56) states that the conditions for the precipitation of lime salts in normal growing bones are the presence of fully developed cartilage cells and the presence of carbon dioxide in the tissues of the cartilage and bone in insufficient quantity to hold the lime salts in solution or to redissolve them when precipitated. He says that in rickets both of these necessary conditions are incompletely fulfilled and in inverse proportion to the gravity of the disease. There is an abundant development of the small-cell elements of the cartilage and scarcity of fully developed cells, and at the same time the free carbon dioxide of the blood is increased, which produce a chronic carbon dioxide poisoning or asphyxia of the growing bone. The lactic acid theory of rachitic production will be considered in due course.

THE BRAIN.

Certain writers have insisted that there is in rickets a faulty development of the brain and pyramidal tracts, but I have never yet been able to substantiate this assertion in actual practice. The increased size of the head does not convey to me the idea of an enlarged brain, but only that of being referable to the thickening of the bones of the skull. Various observers tell us that the brain in rickets is smaller than normal, and that the apparently increased size thereof is the outcome of an excessive amount of fluid in the ventricles; while competent writers affirm that there is an actual increase due to a greater formation of neuroglia, a fibrosis following hyperplasia in other organs. Shuttleworth (Brit. Med.Jour., 1903, ii, 828) is at variance with Trousseau, and holds that rickety children are mentally backward and dull from defective development of the cerebral tissue. Gee insists that the brain is dwarfed in this disease, whereas Jenner speaks of a so-called hypertrophy of the white matter or albuminoid infiltration. Inflammation of the cerebral tissue has sometimes been observed, but is apparently not due to the disease, but some intercurrent cause.

THE LUNGS.

Rickety individuals are very liable to various catarrhs of the respiratory mucous membrane; in not a few instances I have observed the occurrence of fatal bronchitis, bronchopneumonia, pulmonary collapse or emphysema. The retraction of the thoracic walls gives rise to a collapse of the pulmonary tissue, under the depressions,

which is most marked under the beadings;there may also be a compensatory emphysema over the anterior borders of the lungs under the projecting sternum,where there is less support,and where the air vesicles become enlarged from this lack of support.Collapse of large portions of pulmonary tissue may likewise be the outcome of respiratory obstruction from bronchitis,or of other catarrhal condition productive of blocking of the bronchial tubes with a mucous exudation.The lungs on their surface may show signs of pressure from the depressed ribs,and in some cases the beadings of the ribs cause indentations.The catarrh of the respiratory mucous membrane is part of the common incidence to the condition,the affected mucosa being the seat of cellular hyperplasia.

THE HEART.

The thoracic deformity causes this organ to become displaced from its normal position,apart from disease of its tissue itself,the apex being pushed a little to the left.Where it comes in contact with the head of a rib a white patch of thickened pericardium may be observed,and during life this sometimes gives rise to a friction sound;Jenner says that the favourite seat for this white patch of fibrous tissue is the left ventricle a little above its apex,not the right ventricle as in soldiers sometimes under normal conditions wearing knapsacks.Although the heart is,in conjunction with the rest of the body,implicated in the general nutritional insufficiency,it is very rare to find it the seat of organic disease.I have,however,read somewhere of a case of dilatation of the right side of the organ giving rise to sudden death.

THE BLOOD.

Examination of the blood in cases of rickets sometimes gives negative results;and this is curious when we come to consider the part played by the red bone marrow in its formation.On the other hand,the changes observed may be simply those of anaemia,with diminution of the red corpuscles,a deficiency of haemoglobin,and the presence of nucleated red cells.The haemoglobin may stand at from fifty-one to seventy-five per cent.and, with the other changes mentioned indicate a general malnutrition of the haematopoietic organs.Various complications will give rise to their usual blood changes, with perhaps diminution in the haemoglobin and the erythrocytes,as well as a certain amount of leucocytosis, and so forth.

THE LIVER.

The rachitic liver was in former times described as hypertrophic;but this enlargement of the organ,which sometimes may be considerable,is the outcome of the thoracic contraction depressing the diaphragm and displacing the liver down into the enormous belly of these patients.The enlargement in question may therefore be more apparent than real.Cases are on record in which the liver dulness has descended to an inch below the umbilicus,the chest being contracted and deformed from repeated attacks of bronchitis.Cheadle and Poynton (Allbutt's Syst.Med.,iii.,97)describe the occurrence of a diffuse fibrosis,with increase in the cellular components of the organ and a deficiency of earthy salts.This hyperplasia they ascribe to a passive hyperaemia from obstruction of the pulmonary circulation,with a weakened heart and contracted thorax;and refer to such a

case as a result of emphysema and chronic bronchial inflammation.It may happen that this hepatic enlargement is the outcome of the syphilitic dyscrasia,or perhaps it is due to irritation of the liver tissue by a circulating toxin.Severe cases of rickets sometimes present signs of fatty infiltration and degeneration of the organ;or there may be congestion or amyloid infiltration.

THE SPLEEN.

Enlargement of this organ in rickety subjects is by no means uncommon,though the cause of it has been, and still is,mooted.Some authorities hold that it is the result of complications arising in the course of the disease,such as bronchitis or gastrointestinal catarrh or anaemia,whereas Sasuchin(On Rickets,Jahr.f. Kinderh.,1900,p.297)and others insist that the splenic change is the direct outcome of the rickets and characteristic of it.The observer just mentioned examined the spleens of numerous rickety children and found similar lesions in all,viz.,thickening of the capsule and trabeculae,atrophy of the Malpighian corpuscles and narrowing of the arteries,all changes indicative of a chronic inflammatory process.In his control examinations on healthy children he failed to observe these alterations of the organ.It is probable that here again the presence of a toxin or toxins in the blood is responsible for a chronic irritation of the spleen inductive of a hyperplasia.It would seem that sometimes the enlargement of the viscus is due to syphilis in these cases,or sometimes to a coexistent passive hepatic hyperaemia.Koplik reports finding the spleen increased two and a half times its ordinary dimensions;and Hutchinson(Diseases of Children)says that in only one in twenty of his cases was the organ appreciably enlarged during life.Cowan and McClure(Brit.Jour.Dis.Childr.,Aug.,1906)report a study of four hundred and seventeen rickety cases in their service(the Glasgow Royal Hospital for Sick Children);the patients were in various stages of the disease,and in only a fraction over four per cent.(seventeen cases)was the organ found to be eblarged by palpation: so that they conclude that coexistent splenic anaemia, or syphilis,must be responsible for the hypertrophy observed.

STOMACH AND INTESTINES.

The stomach may be found in a state of great distension,in conjunction usually with a certain amount of intestinal catarrh;this gastrointestinal catarrh, indeed,is the condition for which the patients seek relief.The stomach and intestines are dilated,partly from insufficient support afforded by the flabby abdominal muscles,but more often from gaseous distension consequent on fermentative dyspepsia,or perhaps,as Glisson long ago noted and as I have observed in actual practice,from the gluttony of these patients.There is present a general hyperplasia of the mucous structures as in other organs;otherwise there is nothing characteristic in evidence.

THE MUSCLES.

These structures are markedly affected by the rachitic condition.They are not firm and well developed as in health,but flabby and weak,rendering perhaps the patient unable to walk,arise from the recumbent position, or even to raise the head.The microscope shows that

there is some blurring of the striations,and perhaps a certain amount of infiltration or fatty change.As stated, the pot-belly of the disease is due to this muscular change largely.

THE LIGAMENTS.

These are very weak,and under the weight and pressure of the body stretch and produce the characteristic deformities,such as knock-knee,flat-foot,kyphosis,etc. They exhibit no characteristic histological change.

THE SKIN.

Rickety children have usually a pallor of the skin, and sometimes an actual pigmentation is observed.The various dermic structures are unaltered,though there may be,in mild cases,an increase in the subcutaneous fat - obesity in this disease being more common than emaciation.The latter is present when there is some general failure of nutrition or some such debilitating condition as congenital syphilis,The characteristic tendency of the skin of the head to sweat is probably the outcome of the irritation of a circulating toxin or "hyperexcitability of the reflex action of the nervous system"as Cheadle and Poynton(loc.cit.)would have it. Convulsion cases may show subcutaneous haemorrhages,or there may be arrested development of the lobe of the ear or hypospadias.

ETIOLOGY

GENERAL CONSIDERATIONS.

The general concensus of opinion is to the effect that the actual cause of rickets is as yet unknown; and our knowledge of its etiology is at present limited to the conditions that appear to favour its development. Like certain other somewhat obscure affections, rickets has had innumerable predisposing and exciting causes assigned to it, such as heredity, unhygienic conditions, dietetic errors, prolonged lactation, circulating toxins or irritants, indolence, and germs. From time to time these, and a variety of more or less fanciful, theories have enjoyed considerable vogue, but only to be assailed by later observations. That the disease occurs in children who are improperly fed is generally agreed; but that injudicious dieting alone can occasion the malady is not universally believed: otherwise rickets would be much more prevalent than it actually is, even at the present time. The fault of the theories in questions would seem to lie in their local application, most of them ignoring the various constitutional expressions of the dyscrasia from from time to time, according to the case, are observed. In short, too much attention has perhaps been paid to the osseous lesions, and too little to the equally operative constitutional effects.

HEREDITY.

Not a few observers have vaunted the opinion that the children of rachitic parents are, by that fact, more than others predisposed to the disease. Trousseau (loc. cit.) lent the weight of his authority to the idea that individual predisposition is a prime factor in the production of the disease. "This predisposition," he observes, "is often hereditary. No one disputes the part which hereditary predisposition plays in the etiology of rickets: nor that the offspring of rachitic parents are necessarily rachitic, but that it is a fact established by observation, that such offspring is more liable to rickets than others, because the disease more readily develops itself in them under the influence of immediately exciting causes; and because, in particular, that when once it is developed, it is much more difficult to arrest its progress." Most writers are agreed that heredity, - by this term being meant the occurrence of the affection in the parent and the child, - does not play any important part in the production of the malady, beyond the fact that children of parents who have suffered from rickets may be more predisposed, in the same way that tubercular parents are likely to have children more predisposed to one or other of the usual manifestations of the disease. But Seigert (Jahr. f. Kinderh., viii, 129) is strongly opposed to this view and holds that heredity is a more important factor even than hygienic surroundings; he considers that when there is a pronounced family history of rickets, the affection is likely to occur in the child whilst it is still at the breast; the mother hands it on to the child, and he regards as second in importance to hereditary influences diseases of the digestive and respiratory tracts and the moral condition of the parents. It is of interest to consider the four tables which he publishes

in support of his contention.In his first table he includes thirty-one families with rickety breast-fed infants. With the exception of one case,the mother had had rickets or showed some signs of the dyscrasia,in the way of osseous deformity or difficulty of parturition from a rachitic pelvis.In one case the father had previously suffered from the disease,but not his wife.These children at the breast were severely affected with rickets, which for a long time resisted the usual medication and management.In table two there were twelve families,with breast-fed infants without rickety signs,delayed dentition or late walking;there was no history of the disease in either the father or the mother.The third table comprises twelve families also;none of the parents presented a rickety history,though some of the children contracted the disease through,our author affirms,artificial feeding,respiratory affections,or the age or illegitimacy of the parents.His last table includes fourteen families,with artificially-fed infants and parents of rickety histories.Here the affection made its appearance earlier than in breast-fed children,dentition was delayed,and the malady ran a more chronic course and was much more fatal.He tells us that the severest forms of the disease were observed in breast-fed infants with rickety parents. The death-rate of the one hundred and twenty-one artificially-fed rachitic babies was fifty-seven per cent., of breast-fed rachitic babies thirty-six per cent.,and of breast-fed nurslings,immune to the disease,fifteen per cent.That rickets is not hereditary is proved by the fact that children of rickety parents do not always become rachitic.It must be borne in mind also that rickets is a disease of childhood and that the parents,although they may have suffered from it once,are often entirely free from it when they come to mature age.Anything that causes poor health in the mother will predispose to rickets:hence it is a weakly constitution that is hereditary,and the question of idiosyncrasy is also one that must not be disregarded.Another point against the disease being directly hereditary is that we constantly see cases of rickets in which the parents have never shown any signs of the disease.The predisposition to rickets,then,is hereditary;and everyone must have observed this in practices which have included a large number of persons of tender age.Such offspring are more liable than others to rickets under the influence of other exciting causes;and the affection also in persons thus predisposed is often more difficult to arrest than it otherwisewould be.In his work on "Diseases of Children",Ashby mentions the difficulty of securing from the parents a truthful history of the infant's career,it being impossible for them to determine the presence of the affection in the absence of the suggestive osseous deformities.Pfeiffer thinks that the predisposition or tendency alone is hereditary,the affection being actually excited by the shortage of the breast-milk phosphates.Vogel has often encountered cases of rickets in the children of previously-rachitic parents,no prophylactic or remedial measures being capable of preventing the occurrence of the disease in these young patients. According to Jenner,it is very doubtful that infantile rickets can be produced by paternal ill-health;on the other hand,Ritter v.Rittershain claims to have traced the disease to tuberculosis in the father,less often to the latter affection in the mother.Pini presents a

study of four thousand,one hundred and seventy-six cases of rickets;fifty-two of them were apparently of hereditary production,and there was consanguinity of parents in eighty-six;other very probable causes of the affection were also discoverable.Ormerod(Trans.Path. Soc.,xxxii)reports a case in which a father,in childhood rickety and in adolescence the sufferer from mollities ossium,handed on severe rickets to his two daughters.He does not mention the condition of the mother,but does not dispute the theory of the hereditary transmission of the rachitic taint.Jenner regards rickets as an actual diathetic condition akin to tuberculosis or syphilis,though much has been written against this view. Chance(Bodily Deformities)does not for a moment doubt the hereditary nature of the disease.He says that the morbific influence passes directly from the parent to the ovum to influence every stage of its development.He would also have it that many cases of rickets,apparently arising during infancy,are actually congenital and not recognised as such from birth owing to the disease remaining dormant for a time.Forthwith on the child being deprived of the maternal milk and subjected to injudicious feeding,the affection,assisted by the irritations of teething,breaks out afresh in its favourite positions, though the real excitation of the affection can be unquestionably referred to intrauterine life.He refers to an interesting case of foetal rickets in proof of this.According to Cheadle(Artificial Feeding)there is no likelihood of the affection being transmitted,as it dies out in childhood.Much has been written regarding the etiological importance of the factors which operate on the foetus in utero.It is a well-known fact that rickets is especially prevalent in large towns and manufacturing districts,where women are employed in large numbers in mills or factories,and it is also agreed that in such places the conditions of existence are not such as to be favourable to the rearing of healthy and robust children.In addition to this,these female workers commonly return to the factory very soon after childbed;and these children,deprived of their natural nourishment, are artificially fed in a more or less injudicious way. Apart from extraneous conditions affecting the health of the pregnant woman,her general condition of is obvious importance.Should she be suffering from any wasting or chronic disease,it is scarcely possible that her child will be healthy.It is generally believed that the condition of the foetus in utero can be influenced by the health of the mother.The food of the former is derived from the latter,and also the oxygen it receives; while the results of its metabolism are borne away in her excretions.The communication between mother and child is through the placenta,which is said to perform the part of a filter,allowing some things to pass and others not;at different times also it is believed to be more permeable than at others.Thus,certain drugs may pass this barrier,and it is believed that certain micro-organisms may penetrate the placenta and so affect the foetus.In the same way it is likely that certain nutritive materials might fail to pass through the placenta to the foetus,and thereby account for the occurrence of foetal or congenital rickets,of which several authentic cases are on record.Ballantyne advises that,in order to investigate antenatal influences,the placenta in all

cases should be examined, chemically and microscopically, and the results compared with the clinical observations in the child during the earlier period of its mundane existence.

AGE.

Rickets is a disease of the period of the first dentition, apparently by reason of the fact that the effects of improper feeding during the period of early childhood are then most conspicuous. It is seen in children between the ages of six months and two years; but, while this is true in a general way, the affection may occur, however, at an earlier age, even in the uterus, or sometimes at a much later date than the above-mentioned classical time. Out of three hundred and forty-six cases observed by Jules Guérin (loc.cit.) the originations were as follows:

Before birth.....	3	cases
During the first year	98	"
" " second "	176	"
" " third "	35	"
" " fourth "	19	"
" " fifth "	10	"
From the sixth to the twelfth.....	5	"
Total	346	"

(Males - 148; females - 198)

Brueniche gives equally interesting observations as follows:

During the first half-year.....	1	case
" " second "	19	cases
From 1 to 2 years	79	"
" 2 " 3 "	47	"
" 3 " 4 "	7	"
" 4 " 5 "	6	"
" 5 " 8 "	4	"
Total	163	"

Ritter von Rittershain studied five hundred and twenty-one cases, and his results were as follows:

During the first six months of life..	91	cases
" " second " " " "	175	"
From 1 to 2 years	154	"
" 2 " 3 "	62	"
" 3 " 4 "	15	"
" 4 " 5 "	7	"
" 5 " 9 "	17	"
Total	521	"

The age incidence of Ritchie's two hundred and nineteen cases was as follows:

During the first half-year	7	cases
" " second "	65	"
From 1 to 2 years	1 09	"
" 2 " 3 "	25	"
" 3 " 4 "	9	"
" 4 " 5 "	4	"
Total	219	"

Dingwall Fordyce (Brit.Med.Jour., April 28, 1906, p. 971) tabulates one hundred and sixteen cases between the ages of six months and three years, in which the age incidence was as follows:

From 6 to 12 months rickets present in	55 %
" 12 " 18 " " "	63 %
" 18 " 24 " " "	65 %
" 24 " 36 " " "	52 %

In a series of forty-six cases the observations were as follows:

First six months	10	cases
Second " "	14	"
Third " "	12	"
Fourth " "	7	"
During the third year	3	"
Total	46	"

Otherwise expressed, there were:

During the first year of life	24	cases
" " second " " "	19	"
" " third " " "	3	"
	46	"

(In this tabulation of the frequency of the disease during the first three years of life, the ten cases occurring in the first six months of the child's existence are dated from the onset of digestive troubles, which in every instance culminated in undoubted rachitic symptoms.)

The following analysis, by R. W. Parker (Heath's Dict. Pract. Surg., v, 354), of one thousand consecutive cases of rickets is based on the asserted period of onset:

1st year	(1st six months	202 cases	- 20.2%
	(2nd " "	278 "	- 27.8 %
2nd year	(3rd " "	238 "	- 23.8 %
	(4th " "	144 "	- 14.4 %
3rd year		98 "	- 9.8 %
4th year		18 "	- 1.8 %
5th year		14 "	- 1.4 %
6th year		8 "	- .8 %

From this table the frequency of rickets in the earlier months of life, especially in the second half of the first year, is apparent; it likewise shows that it is by no means uncommon during the third six months, and that after the first half of the second year there is a rapid and marked fall in the number of cases. Bishop (Lancet, i, 1848, p. 388) has considered the age incidence of rickets very carefully and remarks that from the "statistical reports we see that the number of cases happening in the first and second years very greatly exceeds that of other periods of life, and that in the subsequent years the numbers diminish very rapidly. The predominance of female cases over those of males may be owing to the greater delicacy of female constitution." Ashby (loc. cit.) has also noticed that the affection in its best-known form makes its appearance from six months to two years, though early indications of the dyscrasia may be observed before the age of six months. Comby (Twent. Cent. Prac. Med.) places the appearance of the disease at from the tenth to the twelfth month; he says that it can come on as late as two years after birth, though very seldom when the child is a year older than that; twelve hundred and sixty-eight of his sixteen hundred and sixty-two cases were from one to two years, and he cites other observations much to the same effect. The following analysis of one hundred and forty-one cases, composed of sixty-eight boys and seventy-three girls, is given by Goodhart and Still (Dis. of Childr.):

Months								Years						
5	7	8	9	10	11	12	18	2	2½	3	3½	4	5	6
3	1	3	2	5	6	11	36	26	19	13	2	6	5	3
Cases								Cases						

Gee(St.Barth.Hosp.Reps.,iv,69)has analysed six hundred and thirty-five cases, three hundred and boys and two hundred and seventy girls, and finds the age incidenceas follows:

Period	Cases
Under six months.....	32
Six to twelve months.....	144
Twelve to eighteen months	183
Eighteen months to two years.....	133
During the third year.....	116
" " fourth "	27

He tells us that rickets was present in thirty per cent.of all the sick children he observed in hospital;but as the patients admission-age only is stated,it is very probable that the disease was present prior to that date.Vincent denies the occurrence of foetal rickets,whereas Starr affirms it.Though admitting the possibility of the onset of rickets much earlier,Hutchinson doubts that unmistakeable signs of the affection are seen before six months - it being usually seen when the child is a year and a half old.Jacobi(Arch.Ped.,1902) recognises the very early occurrence of rickets,especially in the muscles;and he considers a child rachitic which develops constipation when only two or three months old,whether breast-fed or not.In his work on "Bodily Deformities";Chance doubts not that the malady can originate in the unborn child and looks on decayed or anomalous teeth as most suggestive of rickets,as he ascribes them not only to malnutrition after birth,but to some profound constitutional change.He carefully studied no less than six hundred cases,and noticed that two-thirds of them were in the first year of life - which fact he considers as due to the essentially infantile nature of the disease ascribable to some cause operating prior to birth or immediately thereafter.He has compared his results with those of others,and is much impressed with the incidence of the disease by preference before the end of the second year.Some of the mothers said they detected ill-health very soon after birth(one hundred and eight cases during the first month),while a third of the entire series(two hundred and four)were observed during the first six months of life.Only a few of his cases were from two to five years of age;and after carefully considering all the facts he has arrived at the conclusion that rickets is invariably a congenital affection, though it may be,for a few months after birth,arrested and then wake up into activity again.I myself have observed a number of cases,in which the earliest onset noted was six months,the latest two years and six months,and the mean age of incidence fifteen months.In some of them the affection appeared to be due to prolonged lactation. I have noticed that the onset of the disease appears to be earlier in babies reared by hand,and that it occurs in breast-fed infants at a much later period when the mother is feeling the debilitation which pholongation of lactation unduly involves.

SEX.

The occurrence of rickets seems to be but little affected by the element of sex,statistics as to the relative sex incidence of the affection varying considerably.Some writers would have it that girls are more subject to the malady than boys;but an examination of my own cases does not confirm this statement,both boys and

female children being equally affected.The older observers considered that the less robust frames of girls rendered them more prone to the affection.Hall(Physical Deterioration Report,p.89)thinks that "rickets appears to be more common among girls than the boys.The rickety dwarf,with bowlegs,narrow pelvis,and big head is no very uncommon object among girls but rare among boys".In an anonymous series of forty-six cases thirty were boys and sixteen girls.Guérin had one hundred and forty-eight of the former to one hundred and ninety-eight of the latter; Ritter von Rittershain's figures were respectively two hundred and ninety to two hundred and thirty-one; Brueniche one hundred and eight to fifty-five;and Ritchie one hundred and twenty-eight boys to ninety-one girls.Dufour found the number of rickety girls fifteen times as great as that of rickety boys,while Marjolin found that his figures were respectively a proportion of twenty to one.

RACE.

The incidence of rickets is to a certain extent affected by the nationality of the individual.In the United States of America the negroes and Italians are particularly prone to the disease,while in their own countries they mostly escape,though in Italy perhaps the malady is on the increase.So liable,indeed,are the Italians in New York to rickets that even breast-fed infants only seldom escape it.Baker,who travelled extensively in Africa,writing of the customs of the natives in the interior,mentions that there is a system of public night nurseries.Certain houses are built upon stone supports and raised about a yard from the ground. In the clay wall of the circular building there is a round hole about twelve inches in diameter,this being the only way in."At sunset",he informs,"when the children have been fed,they are put to bed in the simplest manner,by being thrust head foremost through the hole in the wall,assisted,if refractory,by a smack behind,until the night nursery shall have received the limited number. The aperture is then stopped up with a bundle of grass if the nights are cool.The children lie together on the clay floor like a litter of young puppies,and breathe the foulest air until morning,at which time they are released from the suffocating oven,to be suddenly exposed to the chilly daybreak".Naturally the mortality is very great and diarrhoea and dysentery kill many of them;yet rickets is apparently unknown.Stranger still, rickets is very common amongst the children of allied races in America.Holt says that these southern races are greatly affected by the temperate climate and confinement of the cities,as there is nothing in their food and mode of living to account for their special liability to the disease.G. N. Acker(Med.Age,xiii,256) holds that negroes are,almost without exception,rickety; that venereal disease is very common amongst them,particularly hereditary syphilis;and that rickets results from the nutrition of the infant thus interfered with.

CLIMATE.

Although no climate debars the occurrence of rickets,the affection is more common in temperate zones, being,according to Barlow and Bury(Encyc.Dis.of Child., ii,p.247),most"prevalent in cold and damp countries subject to frequent changes of weather,such as England, Holland,and certain parts of Germany and Austria,of France,and of Northern Italy".It is very common in the

large towns and cities of America, but is seldom seen in Canada: which fact is in keeping with the general rule that the affection becomes much less prevalent as we travel north or south towards the equator. In Iceland and Greenland and Scandanavia, for instance, the malady is not often seen; in the tropics it is seldom or never observed, and, if present, it is very mild. In contrast with its prevalence in in the north or Italy, rickets is a rare disease of Greece. It is said to be very common among the lower class Egyptians; and the reasons for this prevalence advanced are syphilitic and tubercular parentage, prolonged lactation, bad ventilation, and early marriage. Muskett (Austral. Med. Gaz., 1891, pp. 285-291) says that rickets is very often prevalent in the Australian cities, and even sometimes in the bush. Freeman (Arch. Ped., April, 1904) regards climate and a deficiency of oxygen in the respired air as very important factors in the origination of this disease, the infrequency of which in hot climates he explains by the outdoor lives which both mother and children lead in such localities. This remark would apply also to India (which shows much less rickets than temperate Europe), where, according to Watson (Ency. Med., ii, p. 248), it is limited to the children of soldiers who live in the damp districts and are comparatively seldom in the open air. High altitudes appear to be prejudicial to the occurrence of the malady; on the other hand, low-lying and marshy districts show it in comparative abundance. A cold and damp climate is likely to produce bronchial and intestinal catarrhs, which markedly predispose to the disease. In the same way the affection is more common in the colder months of the year, when they are more confined to the house.

SEASON.

Meteorological factors appear to be operative in the production of rickets, for the disease is more often observed at the termination of the winter season, especially when the weather has been uncommonly cold, damp and gloomy. Children are then kept indoors for the major part of the day, perhaps all day; their vitality is thereby lowered, the beneficent effects of sunlight are also absent, and theyare rendered more liable to the predisposing and exciting causes of the disease. Kassowitz (loc. cit.) says that in Vienna the worst cases of rickets are seen in the winter, and that the difference is more marked among the poorer section of the population, which is just what one might expect, as their poverty and consequent lack of warm clothing necessitate their remaining indoors much more than the more affluent members of society. Edlefsen (Deut. Aertz. Zeit., 1901, 1902) has examined the children in the Kiel and Hamburg hospitals thinks that the incidence of rickets is favoured by season, it being more prevalent there during the winter, when the carbonic acid theory would also obtain or perhaps some sort of infection be present.

LOCALITY.

The home of the patient has much to do apparently with the prevalence of rickets, which is mostly a disease of large towns and cities and densely populated localities, such as London, Manchester, Liverpool, Leeds, Glasgow, Vienna, Berlin, New York, &c. Barlow and Bury (loc. cit.) affirm that, leaving out of consideration the question of craniotabes and directing attention to the junction-area of the fifth and sixth ribs, "there will be no difficulty

in finding at least fifty per cent.of examples of distinctive rickets among children under two years attending the out-patient departments of London and Manchester."Consideration of the published statistics will convince us that at least half the children of the poorer classes under three years of age suffer from rickets. In country districts,though the cases are usually much milder,the affection is by no means uncommon,being especially frequent in isolated hamlets composed of old, badly constructed,dark,damp and insanitary houses;there, too,fresh milk may be difficult to obtain on account of the towns absorbing all the farmers' supplies.The disease is almost unknown in the extreme north of Greenland, Iceland,Norway and Denmark.It is rare in the south of Italy,Spain,Greece,Turkey,China and Japan.In country places there is usually a better supply of milk than in the towns,at least as regards quality;and this fact accounts for the comparative rarity of the affection in rural localities.

INSANITARY CONDITIONS.

An infant that is kept indoors and away from sunlight is very apt to develop rickets;and this is an important factor to be continually borne in mind.In this country,owing to the prevalence of rains,fogs,and so forth,there is much rickets;whereas in sunny China and Japan,for instance,the affection is seldom seen. The narrow courts and alleys,as well as the black smoke clouds which hang over certain places,such as the potteries and the"black country"keep out the health-giving rays of the sun.Although the disease is seen sometimes in the more affluent classes,and those who keep themselves and their houses clean and sanitary, it is an ailment almost peculiar to overcrowded,badly constructed and dirty slums,especially of the large towns.Warmth and sunlight are known to be powerful opponents of the disease,as witness its rarity in tropical climes and the fact that when coloured people born therein remove to temperate zones their offspring have rickets in a severe form.I have already referred to the Italians and negroes in the United States of America as striking examples of this,even their breast-fed infants have the disease severely.In rural places it will usually be found that the malady attacks children who live in cold,badly ventilated,dark,damp and insanitary houses.Not a few of the latter are built with a northern aspect,without through ventilation,with windows that perhaps cannot be opened,and sometimes with no fireplaces in some of the rooms.The front door may open directly into a stone-floored living-room,which is accordingly cold and damp and sunless.Rickety children from these places do well under more favourable conditions;thus I have seen children,who are pallid and puny and unable to walk,pick up soon after their removal to hospital and gratify those responsible for their welfare by a display of remarkable activity.In addition to the fact that children reared in badly ventilated and overcrowded houses,where the sunlight cannot penetrate and where the conditions are otherwise insanitary, show the disease most and in its worst forms,it may be noted that such surroundings have contingent to them the very powerful morbific influence of improper feeding.Even when the predisposition to rickets is not very marked,this want of cleanliness and inspiration of

polluted air,and the like are amongst the most efficient excitants of the disease.Rickets,then,is more or less peculiar to poor childrem,less so of the affluent younger members of the community.Colman(Pract.,Oct.,1905)says it is a disease of modern times and attributable to conditions arisinf from overcivilisation.On the other hand,Cheadle(loc.cit.)affirms that no such factors can be regarded as productive of rickets,he having observed that children with good homes suffer from the disease. He further remarks that he has never seen a child contract rickets,if properly fed and kept from gastrointestinal disorders,even in the most insanitary surroundings. Morse,from a series of three hundred and eighteen dispensary cases in Boston,came to the conclusion that the only rickets-producing influence they had in common was the unhealthiness of their home life.

EXPOSURE TO COLD.

This is assigned an important place by some in the production of rickets,the vitality of the child being thereby lowered and digestive and respiratory catarrhs excited.Poor people not infrequently have the legs of their children bare;should no napkins be worn,the cold wind strikes the abdomen with the above result.Further, the bare skin of the infant may come in contact with chilling surfaces whilst crawling about the home,and there is also every chance of morbific dust being swallowed from the polluted hands.That cold can impair the general health is well known,and the case of the Italians and negroes in the United States of America further illustrates this.Barlow and Bury,whilst admitting the unfavourable influence of prolonged lactation,premature weaning and improper feeding,state that we must also take into consideration insufficient clothing of the infant's limbs.

THYMUS OR THYROID INSUFFICIENCY.

A certain relationship between rickets and a perverted function of the thymus gland has been affirmed by Mendel(Münch.med.Woch.,1902),this conclusion being based upon his observations in cases of atrophy of the gland and from results of treatment with extracts thereof.It has been alleged that an internal secretion of this gland exercises some influence on the development of bone,and that the enlargement of the spleen may be a compensatory hypertrophy,replacement of the absent glandular function being effected by it.Ausset(Gaz.Hebd., 1901)states that the success of phosphorus in the treatment of rickets depends on the fact that it supplies the stimulus to development which is lacking,owing to the deficiency of the thyroid function in rickets.The thyroid gland is rich in phosphates,and its removal from the mother has been said to produce faetal rickets.

MALARIA.

Holt informs us that the symptoms of malaria are sometimes very indefinite in infants,the classical adult phenomena being replaced by pallor,drowsiness,general cyanosis and prostration;in addition,the spleen is apt to be enlarged and marked marasmus present - all of which may cause the cachexia to be mistaken for the commencement of rickets,which is common in cold and damp marshy districts.But it has no connection with malaria as has been suggested by Oppenheimer(Deut.Arch. f.klin.Med.,xxx,1881).This author states that malaria is the principal cause of the disease,or rather his idea is that rickets is the form in which malaria makes

makes its appearance in children of tender age.He thinks very little of the causes of the disease hitherto alleged,and lays great stress on chronic diarrhoea and nocturnal crying in support of his view.The perspiration,etc., accompanying the latter he regards as evidence of malaria,there being a substitution of the same for the intermittent neuralgia of adults,especially in view of the enlargement of the spleen known to exist in rickets. He looks on the diarrhoea of these cases as paroxysmal; it takes place,he says,in the morning and is therefore distinct from the ordinary form of intestinal catarrh. Amongst other facts he adduces to further his claim may be mentioned the serous evacuations not stained with bile,the good appetite during the rest of the day,the absence of emaciation,the gradual development of anaemia,the occasional fever.He also remarks that in certain instances the "infants have cold feet and hands and blue lips towards evening;the skin is pale,the spleen is enlarged;otherwise there are perhaps no symptoms,but the infants endeavour to get uncovered,and have an increase of temperature of from 1.to 3.F.,and a perspiring head in the morning.After a while the rachitical symptoms belonging to the bones and the general system become apparent"Arnstein,Browicz,Henck,and others write to pretty much the same effect.I am quite prepared to admit that the severe forms of malaria which they have observed in certain localities may give rise to rickets, but that the latter is of a malaria nature I emphatically deny in the face of present-day evidence.

TUBERCULOSIS.

From time to time a relationship of tuberculosis to rickets has been affirmed,whereas not a few writers have denied it.Thus Rufz dwells upon the fact that it may be taken as proven that "rickets and tuberculosis or scrofula are not manifestations of the same diathesis,but that,as a general rule,the one excludes the other.This law(also expressed by Dr.Jules Guérin)is so absolute,that you will have,à priori,almost a certainty of not finding tuberculous or scrofulous affections in a rachitic subject,nor rickets in one who is scrofulous or tuberculous.Ritter v.Rittershain found a large number of tuberculous fathers in rachitic families;Sir William Jenner holds that rickets does not negative tuberculosis,and he cites statistics showing that the offspring of tuberculous fathers or mothers show a diminished incidence of rickets.Holt thinks that the chest deformities predispose the patient to tuberculosis,and that under no circumstances can rickets be regarded as protecting the individual against consumption.Eustace Smith does not regard rickets as a diathetic condition, and says that it "never occurs in children in whom the tubercular deposition is well marked"Actual observation has convinced me that rickets has no protective influence against tuberculosis;in fact,I would insist that the rachitical catarrhs of the chest and gastrointestinal tract might form a suitable nidus for the operations of the tubercle bacillus.

SYPHILIS.

Professor Parrot,of Paris,long ago insisted that rickets is merely an expression of congenital syphilis, in which the virus has reached an attenuated stage;but this theory is now acknowledged to be untenable,as one every day comes in contact with cases of rickets in

which there is not the slightest trace of syphilis.Experiment also bears this out.Thus,if puppies of,say, three weeks of age are taken from their mother and fed on raw meat,bread and no milk,they develop symptoms of rickets,as manifested by enlargement of the abdomen, swelling of the epiphyses,curvatures of the bones,and difficulty of walking.Now,if this diet is interrupted, the morbid process is stopped;and on resumption of the diet again the disease returns.The post-mortem findings exactly correspond with those of rickets.It is also known that animals of the kind we are considering do not contract syphilis,so that the hereditary specific disease cannot be the sole cause.Further Parrot was entirely mistaken in his views;for he states that the bone lesion was essentially marked by spongoid tissue, and that without the latter there could be no rickets. He also states that by premature feeding he can produce osteomalacia,but not spongoid tissue.But it is well known now that osteomalacia is a different disease,not an arrest of development;it is an affection in which the already-ossified bones have undergone subsequent softening;further,it is an adolescent disease and has a recognised relationship to pregnancy.Parrot also based his theory on the osseous changes,disregarding the well-known anomalies elsewhere.Besides the clinical history in ~~the~~ rickets and syphilis is different.In congenital syphilis we have eruptions,snuffles,dental anomalies(e.g.,Hutchinson's teeth),keratitis,scars about the angles of the mouth,etc.;whereas in most cases of rickets there are no signs of these.Parrot replies to this that it is a case of transformation of disease,the syphilis having run itself out and made a sort of lightning change into rickets.I have had numerous cases of congenital syphilis under observation,and seldom or never have I seen rickets occur solely from that cause. Syphilis may,of course,accompany rickets;but before it can be decided that the former is the cause of the latter,all other causes must be excluded.Another point urged by Parrot in proof of his theory is the fact that he could cure rickets by antisyphilitic treatment.But it is a recognised fact that rickets tends to cure itself under proper dietetics and tonics;further mercury is a tonic,and the iodides operate beneficially in other affections than syphilis.Again,it is possible that in not a few of Parrot's cases an error of diagnosis was made,owing to the frequent simulation of other maladies by syphilis;thus,syphilitic children not infrequently suffer from periostitis,in which condition there may be enlargement of the ends of the bones.Syphilis may modify rickets,but it never creates it.In certain localities rickets is very common amongst the children of the slums,where syphilis is relatively rare;and the same fact obtains in certain country districts.Syphilis produces changes in the bones analogous to rickets - for instance the condition seen in the cranial bones called craniotabes and the peculiar bosses on the frontal bones;but syphilitic bones do not show the spongy appearance seen in rachitic bones,not do the latter show the multiple osteophytes of syphilis.Before the time of Parrot,Elsasser regarded the sign as pathognomonic of rickets,and the former observer held that it was usually die to syphilis.From all this we may conclude that syphilis is not the exciting cause of rickets,though it may predispose to the latter by lowering the general nutrition of the organism.

OTHER DISEASES.

In some of my cases the incipience of rickets has been referable to the convalescence from one of the exanthemata, such as scarlatina or measles. This is not remarkable, as the unfavourable influence of defective hygiene and improper feeding have at such times a weakened resistance to overcome. The general health of the patient is perverted, and the morbific factors of the disease receive a greater liberty of operation.

PARENTAL FACTORS.

Gelati (Hospital, Oct. 24, 1908) is one of the several observers who have affirmed that the age of the parents may have something to do with the development of rickets in the offspring. He studied the question very fully at Parma, during a period of four years examining no less than three thousand, one hundred and twenty-one children, of whom six hundred and fifteen, or nearly twenty per cent., became rickety. Of these children, seventeen hundred and seventy-nine came from the town, and three hundred and seven, or a fraction over seventeen per cent., showed signs of the disease. Twelve hundred and fifteen were country children, and three hundred and one, or nearly twenty-five per cent., were rickety. The homes of the remaining one hundred and twenty-seven patients were not noted. With regard to the age of the parents, he tells us that in those under twenty the incidence of the disease was, roughly, eleven per cent.; between twenty and thirty ot rose to nineteen per cent.; to twenty-two per cent. between thirty and forty, and to twenty-two per cent. between forty and fifty. He observed that the proportion of cases was always higher in the country-born. Enfeebled nutrition in one or both parents may predispose to the disease, as well as anaemia or any debilitating factor. Early and improvident marriages, in addition to advanced age at the time of procreation, may have a good deal to do with the occurrence of the affection.

BACTERIOLOGICAL CONSIDERATIONS.

From time to time observers have held that rickets is due to a microorganism or something of the nature of a toxin, such facts as the following suggesting it: (1) The osseous lesions of the disease are of such severity sometimes as to be comparable to an acute inflammatory process, which may affect other parts of the system (2) This excessive hyperaemia is such as would suggest the presence of a circulating toxin, probably absorbed from a diseased digestive tract. (3) There is in rickets a period which may be regarded as prodromal, during which time constipation, indigestion, perhaps diarrhoea, and general perversion of nutrition and debilitation are observed. (4) According to Ashby (loc.cit.) allied toxins are responsible for the variety of morbific phenomena observed - either the classical symptoms in the bones or constitutional effects pure and simple. (5) Special symptoms can only be explained by a bacterial cause. Despite such factors suggestive of the possibility named, no specific microorganism has yet been discovered, though the research conducted for the detection of the same has been assiduous. Impressed by the intense affection of the bones and the febrile rise sometimes seen in the course of the disease, Mircoli (Gaz. degli Osped., Jan. 30, 1898) conducted special observations, which culminated in his reporting that he found streptococci and staphylococci present constantly in the mammary ducts of women who were suckling, and also in the mouths of their

nurslings.He would have it that these germs,which are innocuous in the case of the healthy infant,become pathogenic when there is any gastrointestinal disturbance, with the result that rickets ensues.The organisms,having become pathogenic,attack the system generally,but select those parts which are in a state of most active growth, such as the epiphyseal ends of the bones,giving rise to the characteristic enlargements in these situations,and also the nervous system,giving rise to reflex nervous irritability,convulsions or laryngismus stridulus.Our author considers that the changes found in the osseous system are due to chronic osteomyelitis,and advances as evidence the fact that he has produced enlargement of the epiphyses in young rabbits seven or eight days old by injecting small quantities of cultures of the staphylococcus.In view of the unclean condition of many of the nursing mothers and the objectionable habit of using artificial teats or soothers,which are dropped on floors or bedclothes none too clean,and then placed between the infant's lips which may be very dirty,it is not surprising that such germs as those mentioned are to be found here.Murpurgo claims to have discovered a way of producing rickets by injecting rats with a diplococcus, but his results have not been confirmed by others.Spellman inoculated animals with small portions of rachitic bone,and also with the diarrhoeal stools of rickety infants;but he was able to produce rickets in one only out of one hundred and twenty-seven experiments.In 1860 Friedleben found an intestinal ferment,which,regarded as operative in the disease.Kassowitz believed in the activity of microbes,but refuses to subscribe to the theory of the toxaemic cause of rickets,for the reason that the latter is more common in the winter and gastrointestinal catarrh in the summer.But this objection has been answered by the fact that the development of rickets is so slow that it is quite possible for its incipience to occur during the summer and lay the seed for the winter phenomena of the affection.He himself admits that the commencement of rickets may be inaugurated long before the winter,and perhaps be traced back to the very early days of life or even to intrauterine existence.He has never seen a sudden occurrence of the disease.Volland thinks that rickets is due to a specific virus,the nature of which is not yet understoodChaumier(Med.Inf., 1894)says that rickets is produced by an epidemic contagious germ which lurks in certain dwellings.Hagenbach-Burckhardt(Berl.klin.Woch.,1895)considers the osseous lesions and the splenic enlargement as expressive of a profound infection.Marfan and Marot(Rev.Mens.,1893) claim to have found the bacillus coli commune and the streptococcus pyogenes in the blood of rachitic infants with gastrointestinal catarrh.Czerney and Moser(Jahr.f. Kinderh.,xxxviii),in addition to these organisms,and under similar conditions,found the bacillus lactis aerogenes.Ettore(Rev.Mens.,1897)found various organisms, sometimes in the bones.Charrin and Gley(Soc.Biol.,Paris, Feb.22,1896)fed female and male rabbits on cultures of the diphtheria bacillus and the bacillus pyocyaneus,and noted the development of rickets in the litter.Lange (Verhand.d.12,Vers.d.Ges.f.Kinderh.im Lübeck,1895,p. 144)would have it that some infectious principle is attached to certain climates and localities,as in cretinism;and for the reason that in such rickets-free places as China,Japan,Finland,Iceland,etc.,unfavourable

hygienic conditions and other alleged excitants of the disease obtain.Edlefesen(Deut.Aertze Zeit.,Sept.8,1902) says that many of these cases are accounted for by cold and poisoning by carbonic acid,though some ofthem may arise from residence in infective dwellings.Such a residence,it seems to be,would operate merely by producing a predisposing perversion of vitality and not the actual disease.Speleman's researches are interesting in that he exposed various laboratory animals to the same unhygienic conditions and dietetic defects which are held to occasion rickets,and found that,though they all died from gastrointestinal disease,none of them showed rachitic symptoms.In spite of all this,I consider it very doubtful that microorganisms are the actual cause o f rickets;it is far more likely that toxins derived from the digestive tract,as a result of dyspepsia and perverted nutrition,absorbed and circulated in the blood stream, are mainly responsible for the various phenomena of the disease.I admit,however,that the climatic distribution of the malady is apparently opposed to the idea of an intestinal intoxication or toxaemia or microbic infection,but would emphasise the fact that the absence of rickets in tropical and other rickets-free localities is due to the open-air life of the inhabitants.

DIETETIC CONSIDERATIONS.

The diet of the infant has been variously assailed for the production of rickets,and the theories regarding it are almost as numerous and at times fanciful;only a few of these,however,need here be considered.Marchand, Otto,and Weber were strong advocates of the idea that the bones of rachitical individuals contain lactic acid and lactates,and that these had the action of dissolving the phosphate of lime,normally present in osseous tissue, and lead directly to bone-softening.Drivon(L'Union Méd., Sept.,1867)analysed a number of rickety bones and found that lactic acid was present therein.Peter(Clin.Med., v,74)says that there is a connection between the presence of lactates in the bones and the profuse sweating characteristic of the disease.According to him,the essential process is the production of lactic acid,which is eliminated partly by the perspiration,the other part remaining in the system and acting upon the inorganic constituents of the osseous tissues.On this question observers resolve themselves into two schools,the one urging as a cause the absence of certain bodies in the food and the other the presence of some acid,or acids, in the circulation of the patient.Chossat,in 1842,advocated the first theory and fed pigeons on food deficient in lime salts,with the result that he was able to produce in them a condition in which the bones were readily liable to fracture.But Friedleben,while finding that the bones were more fragile than normal,maintained that the characteristic lesions of rickets were absent.Voit repeated these experiments in 1880,and came to the concl-usion that rickets was actually induced.Bagihsky concluded that the administration lime-free food gave rise to rickets,and that the changes in the bones were more marked when lactic acid was added to the dietary.Barlow and Bury(loc.cit.)say that,while although the deprivation of lime may be responsible for the production of the disease,the result should be attributed "not directly to the withdrawal of mineral constituents from the food, but indirectly to irritation of the delicate ossifying

tissues by the altered nutrient juices!They urge against the theory that,first,slight though characteristic rickety changes,such as increased vascularisation and proliferation of cartilage,may occur when the bone is normally calcified;and Krukenburg has demonstrated that the ash of uncalcified cartilage consists mainly of lime.Secondly,in mild forms of rickets the calcification of the cartilage covers a larger area than normal.Thirdly,cow's milk is much richer in lime salts than human milk,and yet the great majority of cases occur in artificially-fed children.In this connection it has also been stated that the custom of farmers of allowing milkh cows to be served six weeks after coming in season,and that ninety per cent.of the milk consumed in this country is obtained from cows in calf,must be operative. Hence Stephens(Hospital,May 2,1908)suggests this fact as a cause of the disease,as he considers that the growing embryonic calf uses up a large amount of calcium at the expense of the milk.But the production of calcium,even in the case of a cow in calf,to that of human milk is as .7 to .3;and Wright considers that cow's milk often disagrees with infants from its overrichness in lime salts,and recommends decalcification. Lastly,the administration of lime salts does not cure rickets,and a cure may take place,even when the child is kept on the same food.The second theory,the lactic acid one,has enjoyed a considerable popularity.Schmidt and Drivon claim to have found lactic acid in the bones of patients who have suffered from osteomalacia;and the latter observer says that lcatates were present in rickety osseous materialThey suggest that the acid is the product of fermentation in the stomach,as a result of indigestion,and that it is absorbed into the circulation,by means of which it is carried to the bones.Virchow,on the other hand,found that the medulla of long bones in these cases was invariably alkaline in reaction.The results obtained from various researches have been very contradictory.Marchand,Lehmann,and others have detected lcatic acid in the urine of rachitic individuals;but Neubauer could not find it even in a case of severe rickets.Marchand and Lehmann found an increased amount of phosphate of lime in the urine;but Zuelzer proved that neither lime nor phosphoric acid was present in excess.Heitzmann gave lactic acid in the food and hypodermically to carnivora and produced rickets in them;but the food was also deficient in lime and there were,in addition to the rickets,great emaciation and bronchial and gastrointestinal troubles.Others have repeated these experiments without the production of the disease,and Korsakow's experiments on dogs gave only negative results.Seemann holds that there is a deficiency of hydrochloric acid in the gastric juice,and that,as an outcome of this shortage,lime salts do not enter the blood,but are excreted by the intestinal tract.In view of the influence of improper feeding on the occurrence of rickets,the proper methods of alimentation of infants should be well understood.The food of an infant consists of the same elements as that of an adult,viz.,proteids, fats,carbohydrates,mineral salts and water;and,as in the case of adults,there is a constant waste and a constant repair.In the case of infants the food must be supplied in a suitable form;and the relative quantities in which the several constituents are needed differ in infants from adults.The digestive organs of infants are not

perfectly developed,so that only certain kinds of food can be digested without producing disease.The secretion of saliva is not established until about the fourth month,and prior to that age starch cannot be properly digested.In spite of this,mothers often give farinaceous food too early.The various tissues of the body are continually undergoing nitrogenous waste,and a supply of proteid is necessary to keep them in proper condition.If this is wanting,the whole system suffers and no other food constituent can make up for its loss.So it comes that proteid is the great tissue-builder.Alone for a time it can sustain life and prevent loss of weight;but in order to do this,it must be taken in excessive amount. It will then tax the digestive organs and the kidneys. If therei s too little proteid in the food,anaemia and perversion of nutrition result,as well as rickets in due course.The fats prevent nitrogenous waste,and are thus of great assistance to the proteids;for the rapidly growing organism needs all the proteid it can get.They are also a source of animal heat;and,in addition to this,provide the necessary adipose tissue.They are also necessary to the proper growth of bone,nerve cells and fibres.Probably they assist in the growth of bone by stimulating the absorption of inorganic salts from the intestine.They have a laxative effect.Insufficiency of fat in the food is capable of producing rickets,but especially if there is a deficiency of proteids as well. The carbohydrates are very important to the infant,they allow of the priduction of animal heat and assist the proteids by preventing nitrogenous waste.By being partly converted into fat they assist in the formation of the latter in the body and lead to the infant putting on weight.In milk the carbohydrate is milk sugar.In view that many of the popular infant foods(sic)contain an excess of carbohydrates,it must be remembered that this fact in itself may lead to rickets,although the child is quite plump and as apparently healthy as the mammoth posters on the hoardings would have us believe.The mineral salts perform the important part of building up the bones and assisting the growth of the cells of the body;they are mainly phosphates of lime and magnesium. These inorganic salts are constituents of the blood and digestive fluids;absorption,excretion and secretion are efficiently performed under their assistance.Water forms about ninety per cent.of the food,the elements of which it holds in solution or suspension;rapid elimination of tissue waste could not be effected without it.All these constituents are to be found in proper proprtion in the milk of a healthy mother,the composition of which,according to Holt(loc.cit.)is as follows:

	Average	Common Healthy Variations
Fat	Per cent.	Per cent.
	4.00	3.00 to 5.00
Sugar	7.00	6.00 " 7.00
Proteids	1.50	1.00 " 2.25
Salts	0.20	0.18 " 0.25
Water	87.30	89.82 " 85.50
	100.00	

The same observer tabulates the constituents of an average cows milk thus:

	Per cent.
Fat	3.50
Sugar	4.30
Proteids	4.00
Salts	0.70
Water	87.00
	100.00

From the above it will be seen that cow's milk contains more proteid and fat than maternal milk.This difference in the amount and character of proteids and their indigestibility may be assigned a foremost place in the difficulty of feeding infants properly on cow's milk.The maternal milk forms small curds in the stomach, but cow's milk forms large ones incapable of easy digestion.Further cow's milk contains a number of bacteria, whereas the secretion of the human mother is absolutely sterile as a rule.Dilution of cow's milk is performed in order to dilute the amount of proteid and fat to nearer the percentage of maternal milk;but sugar has to be added to cow's milk in order to bring up the sugar standard to that of the human being.Infants who are breast fed do not usually develop rickets,and when it does occur it is usually of a mild type.The following table shows the occurrence of rickets in two hundred cases classified according to the nature of early dieting,and is given by Fordyce(Brit.Med.Jour.,Apr.28,1906, p.971):(a)Breast Feeding.Children,wholly or mainly on the breast for from eight to twelve months and also children aged from six to eight months at date of examination,who had up to that period been nursed wholly or mainly on the breast.(b)Hyperlactation,that is, children reared wholly or mainly on the breast for over twelve months.(c)Mixed feeding,that is,children reared partly on the bottle and partly on the breast for from two to eight months,and also,children reared on the breast for from two to eight months.(d)Bottle feeding, that is,children reared entirely on the bottle,or where breast nursing lasted for less than two months:

Nature of Early Feeding	Rickets		Total Rickets	No Rickets	Total Number of Cases
	Marked	Slight			
(a) Breast	18	27	45	45	90
(b) Hyperlactation	10	8	18	13	31
(c) Mixed	5	5	10	5	15
(d) Bottle	28	15	43	21	64

This table shows that the amount of rickets in mixed-fed infants is nearly the same as in the bottle-fed;but in the case of the former the percentage of marked instances was fifty,but in the latter a fraction over sixty-five.I have seen rickets in breast-fed infants several times;but have from extended observation come to the conclusion that so long as the mother is healthy,has a good supply of milk,and attends to the regularity of feeding,there is very little risk of her child becoming rachitic.If,however,the milk supply is poor and the feeding is irregular,the disease will almost certainly occur.The reason for the increase in the prevalence of rickets may be sought in the fact thatthere is a growing tendency for mothers to resort to artificial feeding,especially in the case of the upper classes with their innumerable exacting social calls.But the affection is also very common in the

middle and lower clases,which comprise mothers who are willing to nurse and cannot and those who can and will not - the latter kind being,according to my experience, particularly common.Anything likely to unfavourablyn affect the milk of the nursing mother may produce the rachitic condition in her child,particularly starvation or perversion of nutrition from any cause.Thus the affection is very common amongst the poor.Prolonged lactation has been known to produce rickets in this country, though infants are suckled for a long period in Japan, where the disease is practically unknown.On the other hand,premature weaning is often the starting-point for the affection.But it is also true that such things as premature weaning,prolonged lactation and improper feeding have perhaps been given greater prominence and importance than they really deserve:for the offspring of women with a good supply of milk may become rickety and artificially-fed infants sometimes escape the disease. Darkness,bad ventilation,cold and deficient clothing,etc., undoubtedly contribute to the malign influence of defective dieting.In itself the latter factor does not cause the malady:rather does it give rise to marasmus,which does not usually coexist with rickets.In the case of out-patients and other poorer membersof the community especially,it is no uncommon thing to find that the children have been suckled for as long as twenty months; and such infants are largely rachitic,the first signs of the disease not appearing until perhaps the second year.Experiments on animals have given variable results. Guérin produced rickets in puppies by feeding them on meat when they should have been drawing milk from the mother;but Tripper,who experimented on cats and dogs, failed to do so;and Baxter likewise failed with starchy food,though again the animals died of inanition.The difficulty here lies in the fact that,in order to produce rickets,there must be assimilation of a certain amount of food;but these animals could not assimilate enough nutriment to keep them alive.Cheadle and Poynton (Allbutt's Syst.Med.,iii,823),on the other hand maintain that rickets is excited by a rachitic diet,just as scurvy is occasioned by a scorbutic one.They mention that children reared under favourable conditions as regards warmth,fresh air,sunlight and cleanliness,when artificially fed,do become rachitic,and that these patients may be cured by a suitable diet,i.e.,by an antirachitic feeding course as certainly as scurvy is eradicated by antiscorbutic food.But there can be no doubt that rickets is remarkably common in this country amongst artificially-fed infants,particularly when the food consists of such things as sopped bread,condensed milk and milk that is not fresh or of proper quality,though children reared on fresh milk or milk and cream do not invariably escape the disease.In the latter case it will often be found that the infants have been overfed,with more or less severe gastrointestinal catarrh as a result.Vomiting and diarrhoea,with the passage of large quantities of undigested milk in the stools,are the symptoms in these cases,and not the characteristic rachitic anomalies at first.Bland Sutton's experiments are well known to students of this disease and quoted by practically every writer upon it.He produced rickets in the young apes at the London Zoological Gardens by feeding them on a vegetable diet,chiefly fruit,and also in young

bears by means of a diet of biscuits,rice and raw meat; the latter animals had rickets so severely that they died.The lion cubs used to be weaned early and fed on raw meat,with the result that they became so rachitic as to die.Out author advised the addition of pounded bones,milk and cod-liver oil to the diet;rickets forthwith disappeared,without any change in surroundings of the animals,and the cubs thereafter reared were very strong and healthy.The natural diet of all these young animals was milk:deprived of that,they developed the disease.From this it follows that deficiency of fat and proteid tends to produce rickets,especially when the surroundings are bad;in the case of the bears and monkeys,there was a shortage of proteid and fat was almost entirely lacking;the diet of the lion cubs,though rich in proteids,- lean horse and goat flesh,- was almost devoid of fats and lime salts.The experiments in question have been considered by many as crucial and conclusive as to the production and cure of rickets by fat and bone salts,with some casein and lactose.We may take it, then,that infants who are fed on sopped bread,condensed milk of poor quality,cornflour,or most of the patent infants' foods so-called,are deprived of three essential elements,viz.,fat,proteids and earthy phosphates; and as,in the case of the slum population,defective hygiene and absence of sunlight andfresh air,etc.,are usually superadded,rickets is commonly observed.When the disease occurs in children fed on fresh milk there is usually overfeeding,and then ensues lactic and butyric fermentation.It seems likely that artificial foods, by their excess of carbohydrates,prevent the assimilation of what little fat there may be present,an excess of these probably producing fermentation and so interfering with the digestion of the fats.Chalmers Watson(Lancet,Dec.18,1906)once fed some female rats,for some time prior to pregnancy and during the period of lactation,on a liberal diet of meat(ox flesh),the young of these rats after weaning being similarly dieted;control animals received bread and skim milk.The animals were killed and there was observed a general softening of the bones in all of the meat-fed animals,which same seemed to have advanced in proportion to the time they were thus fed. The long bones,and particularly the ribs,were dark in colour from the excessive blood supply present.The ages of the rats at death varied from one day to three months, and in the case of those aged two months there was curvature of the spine and long bones,as well as lordosis, bending of the ribs at the angles,and a certain amount of distorsion of the bones of the limbs.The ribs were beaded in about a fifth of the cases.These beady,white prominences were seen on section to consist of cartilage in the same condition of alteration as in human rickets.The bone marrow showed a great excess of fatty material and hypervascularisation.But the epiphyseal ends of the bones were quite normal,so that some condition other than rickets must have been in operation,- which fact may be taken to throw some doubt upon Guérin's statement that he occasioned the disease by an exclusive diet of meat.Watson refers to a case in which a human tuberculous mother,who consumed a large amount of meat, married and became pregnant.The child was brought up on the bottle and at the age of twelve months became anaemic;the administration of raw meat-juice made the condition

worse,and the child died.The symptoms during life were not unlike those seen in meat-fed rats and after death the osseous conditions were somewhat similar also.This case shows the great influence that the diet of the mother during pregnancy may have upon the offspring;and the fact is one which should always be borne in mind. Various other experiments have been conducted to show that a disease very like human rickets can be produced in certain animals improperly fed.Crisp(Trans.Path.Soc., xxviii)made use of chicken,which had been kept under unfavourable hygienic conditions and were badly fed.The bones were seen to be softened and distorted.I have had some experience of dog-rearing and have had several cases of rickets amongst them from improper feeding,and have noticed signs of the disease in various animals kept in places that are cold and damp.Tripier could kill cats and dogs and chickens with a meat diet,but in none of them could he produce rickets.Baxter's starch-fed experimental animals died of marasmus,but were not rachitic.This fact he(Trans.Path.Soc.,xxxii)attributes to the marasmic fatality not allowing of sufficient time for the malady to develop,and he seems to think that the so-called rickets in animals may not be the same as the human disease.Am American observer,Herter,failed to produce rickets by excluding fats from the diet of pigs, though constipation,debility,muscular weakness,drowsiness,and sometimes diarrhoea occurred.Though far starvation in the case of pigs is inoperative so far as rickets is concerned,the contrary is true as regards human beings. Thus Cheadle(loc.cit.)tells of the case of an infant in the country reared on skim milk and farinaceous food;it developed rickets,which,however,was in due course cured by the addition of fat to the food.Deficiency of fat in the diet of an infant is therefore of great importance; in good milk it is abundant,but when the milk is skimmed the contrary obtains.A child fed on such a poor milk will develop the disease;but if fat be added or cod-liver oil be administered a cure will result,and especially if raw meat-juice be provided as well.But too much fat is almost as bad a too little or none;for then indigestion and intoxication may occur and a marasmic condition ensue.Too much cream should therefore not be allowed in the milk,as I have often observed the same give rise to dyspepsia,vomiting,diarrhoea or constipation and renal insufficiency.Such children may lose flesh or become rachitic,the fat interfering with the proteid absorption.It is important to bear this in mind in endeavouring to rear infants on milk modifications.The carbohydrate in human milk is inoperative from the stand-point of tissue-building in the early days of infancy, ptyalin ferment being absent from the saliva up to the second month and the diastatic one from the pancreas until the twelfth month.Shaw's experiments,one hundred in number,showed that in the saliva of very young infants there is a diastatic ferment which converts a certain amount of the starch into maltose;that the diastatic salivary action may continue in the stomach for two hours after meals;and that the infant can most likely digest starch in small quantities.According to White (Milk Coagulation and Digestion),digestion or modification of the curd may be materially assisted by the presence of such a small amount of starch as 0.7 per cent., comversion of starch into dextrin lessening the effect upon the curd.Holt says that a sugary diet may cause the

child to put on weight,with,however,the probability of rickets,there being no proportionate gain in strength and only a feeble muscular system and lowering of disease resistance.It is quite easy to make a baby as fat as those on the posters of the patent food people,and yet have it anything but strong.The tendency nowadays is to regard rickets as a general disease caused by poisons or toxins absorbed from the alimentary canal; and this idea would seem to be in accord with the numerous and varied clinical phenomena ofthe disease.

SYMPTOMATOLOGY

GENERAL EVOLUTION OF THE DISEASE.

Rickets is an affection of very gradual development; it having no characteristic early manifestations, it is usually by no means easy to determine the exact time of its commencement. Certain early morbific phenomena have, however, been considered by certain authorities as more or less characteristic. Thus Trousseau (loc.cit.) regards as particularly suggestive of the rachitic dyscrasia in its incipience certain modifications of the mental condition of the child. According to him we find a "certain kind of sadness analogous to that observed in cerebral affections, or, still better to indicate its nature, analogous to that gloom which takes possession of children who are hatching - forgive the expression - who are hatching the malady we term cerebral fever.... This mental gloom of rachitic patients depends, according to all appearances, upon their exquisite sensibility in every part of the body, a sensibility which I have been anxious to point out to you, which shows itself by eliciting painful cries of pain when an attempt is made to raise up the young patient. The unfortunate little creature, who up to then was enchanted by the caresses lavished upon it, appears now to be afraid of them; even an approach to the bed on which it lies, made as if with the object of changing its position, causes its countenance to express anxiety and fear. This change in the child's character, this fear which it shows of having pain roused up by the pressure of the hand, this habitual stamp of sadness on its countenance differ from anything seen at the commencement of serious maladies, particularly from the prodromata of cerebral fever. Indeed, in a child stricken by that cruel affection, we can still produce a transient cheerfulness, causing it for the moment to emerge from its habitual melancholy langour. In the rachitic child this is impossible. The more we try to excite it, or induce it to move, the more will it manifest impatience. It is heedless as to the games of which, formerly, it was so fond. This repugnance to the amusements of its age, this habitual sadness in a child, which, with an appet-ite increased rather than diminished, loses flesh visibly, which has always an acceleration of the pulse coincident with profuse sweat, are symptoms, I say, which have a certain meaning; for the child does not cough, and presents no sign which can give rise to a suspicion of the existence of tubercular phthisis. These phenomena, in proportion as the child begins to walk, become more and more evident; the fever, or at all events, the acceleration of the pulse continues; the skin is constantly covered with profuse sweat, whether the patient be sleeping or walking, or whether more or less covered than usual. The excessive perspiration is greatest in the head, and it is on that account necessary to change the child's cap and pillow-case several times a day, so quickly do they become soaked. I have frequently been impressed with the insidious nature of the onset of rickets. The little patient appears at first to be out-of-sorts, fretful and restless, particularly from sunset till morning. There is often a certain amount of dyspepsia and flatulence, and not infrequently some diarrhoea, together with

the passage of undigested milk in the stools, which latter are not infrequently of a greenish hue and possedded of a very offensive odour. During the time that the child is in bed it becomes heated and therefore tries to throw off the bedclothes; it sweats profusely, especially about the head and neck. The infant may throw its head about on the pillow so much that the hair becomes thin through the boring action of the cranium thereon. The child, especially when severely affected, resents being handled; it stares at its mother with a solemn and owl-like expression, which changes to one of alarm and despair when she comes closer to it; it screams when she attempts to move it. The teeth are late in cutting the gums; they often do so irregularly and with considerable constitutional disturbance. The infant makes little or no attempt to walk, preferring to sit resting with its hands on the bed or floor, with probably bent forearms, and rounded back. There is sometimes much emaciation; but usually the infant is fatter than normal, though pale and flabby. The head appears to be large and quadrate; the anterior fontanelle remains open for a long time, while the face by contrast may appear abnormally small and wizened. The chest is not normal in these cases. The breast bone projects forwards, a row of beady prominences may be seen at the chondral ends of the ribs, just outside the vertical depressions on each side of the sternum; and there may usually be seen transverse sulci just below the nipple line on each side. In contrast to these transverse constrictions, the lower ribs are everted above the large belly, which is so prominent a feature of the disease. The muscles, and particularly those of the belly, are soft and flbby. There is usually enlargement of the epiphyses at the wrists and ankles; and, if the affection has commenced after the child has started to walk, there will probably be seen bending of the bones of the lower extremities. But it must be remembered that the above typical course of rickets is by no means invariably pursued, as it sometimes happens that only a few of these phenomena are seen, or, in rarer instances the morbific expressions are of much greater severity and characterised by marked osseous deformities and such intense nervous anomalies as laryngismus stridulus and convulsions. The variety of the affection known as acute rickets is seldom seen; it is characterised by a tendency to febrile elevations and severe constitutional disturbances, though it seems likely that rickets is not alone the cause. Although in a severe attack of rickets the patient appears to be very ill, the danger to life is not in proportion to the intensity of the phenomena observed. The affection in itself is seldom, some writers say never, fatal. It is the complications which are so apt to kill the child, particularly disease of the bronchi, lungs, intestines and nervous system. It is very important that the early indications of the disease should be detected, in order that the proper treatment may be forthwith instituted. During the period immediately after birth the infant is practically helpless and performs only reflex actions; but, if in normal condition, it should be able to hold up its head about the third or fourth month of its life, to sit up at the ninth or twelfth month, to make some attempt at walking at from the latter month to the eighteenth, and to indulge in baby-talk at the twenty-fourth month. During all this time it should be becoming heavier, and with such progression that it has doubled its birth-weight by the

fifth month and trebled it by the time it is a year and a quarter old.The mouth of every suspected case should be carefully examined for the evolution of the teeth.The first tooth should be seen at about the sixth month,at the so-called "half-time"of the first year;and all the temporary teeth should be through the gumes by the time the child is three years of age.Then the head should be examined for fontanelle signs.The anterior one is the most important;it normally closes at about eighteen months or two years - a fact which it is very necessary to bear in mind.To such signs as these Hutchinson has given the name of"milestones" - a by no means imappropriate term.He recognises three of these,viz.,first,the teeth-cutting age;second,the anterior fontanelle closure; and,third,the erect-posture assumption.In rickets there is a departure from the normal course of events;and,from the above description,it will be seen that the child is late in reaching its milestones.Carefully studying the case in this way,the incipience of rickets will usually be detected with comparative ease,whereas otherwise it might escape attention.It is very important that an error in diagnosis be not made through the fatness of the patient;a rachitic infant is frequently plump:it may be as fat as in health,but the flabbiness of the muscles will suggest the disease.The anaemia,the general muscular weakness,and the constipation or diarrhoea are very suggestive at this stage.Carmichael thinks that frequency of micturition is an important early sign of rickets;some hold that there is a peculiar odour in the renal secretion passed,whereas others,such as Baumann (Jahr.f.Kinderh.,July 18,1906,p.212)deny this and affirm an acidity of reaction without increase of the ammonia present.Bronchial catarrh is sometimes one of the earliest signs of the disease;in other cases there is great nervous disturbance and the phenomena presently to be described in detail.

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THE PRINCIPAL SYMPTOMS IN GREATER DETAIL.

The symptoms of rickets are so numerous and varied that it is undoubtedly convenient to consider them separately as is here proposed.Some writers even go the length of formulating classifications,according to the nature of the symptoms predominating in a particular case.Thus we read of catarrhal, gastrointestinal,osseous, pseudoparalytic,acute,foetal and late types of rickets. The last two types are well recognised and will be fully described presently.The catarrhal variety is that in which there are at first repeated attacks of such a catarrhal affection as bronchitis,with development of the osseous anomalies at the tenth month or later.In the second-mentioned type the deformities of the bones follow various gastrointestinal disturbances.In the third type there is an absence of early general symptoms and the deformities appear without anything in the nature of prodromes.The pseudoparalytic is sometimes called the acrobatic;though the child is not actually paralysed,there is a marked flabbiness and weakness of the muscles.

OSSEOUS SYSTEM.

GENERAL CONSIDERATIONS.

The alterations in the bones produced by rickets are the outcome,as I have already shown,of delayed and

imperfect ossification, abnormal resorption of osteoid tissue and hyperplastic processes. In certain cases it is necessary to properly estimate the disease present by taking an all-round view of the condition of the child, carefully weighing it, measuring the head and chest and belly and noting the proportions, and then investigating the tonicity of the muscles and general nutrition of the patient. As already stated, one must beware of being mislead by the apparent fatness of the child; in these cases there will usually be found an alteration in the normal ratio between the head and chest and belly, which same Rotch (Pediatrics) gives as follows:

	Early Weeks	Six Months	Twelve Months
Head	13½ inches	17 3/8 inches	19 inches
Thorax	13 "	17 3/8 "	19¾ "
Abdomen	14 "	18	19.

Bearing in mind the above, it will be found that under normal conditions the chest gradually gains upon the head and abdomen and ultimately exceeds them. But, in the case of rickets this is not so: the head and belly are too large and measure more than the narrow chest.

THE SKULL.

Dimensions.- The head of a rachitic infant appears to be large and out of proprtion to the small face, the enlargement being principally due to the thickening of the cranial bones. Trousseau (loc.cit.) was of the opinion that the big skull indicated precocity, but this is not in keeping with the modern views of the disease. The condition is one of malnutrition generally, and in this the brain shares. Jenner says that it is often hypertrophic; while Gee holds that it is small. Several writers affirm that it may be enlarged, as are the ends of the long bones - a sort of fibrosis, or that it may suffer like the muscles and be atrophied, while the ventricles contain an excess of liquid. It should be specially noted that this increase in the size of the head is more apparent than real, as actual measurement will show. Holt (loc.cit.) has made a number of measurements and found sometimes an actual increase of cranial circumference of one or two inches. This, however, as stated, may be assigned to the thickening of the bones.

Shape.- The alteration of the head in rickets is an important sign of the disease. It is quadrate or square or box-like, the skull being long from before backwards or dolichocephalic. The forehead is broad and prominent - the so-called Olympian forehead - through enlargement of the part in the form of bosses over the frontal and parietal regions, with perhaps development of cellular cavities in the bone. The top of the head is flat through separation of the parietal from the temporal bone and the retroversion of the occipital. The temples and the occiput are also flattened from pressure, Parrot's bosses being in these situations well-marked; Carpenter regards these bosses as syphilitic expressions, and also of great frequency in rachitic children; Parrot was likeise of the same opinion. Various observers have disproved this view. The occipital bone is flattened by pressure upon the pillow, and the brain is pressed forwards against the frontal bone. But the centres of ossification have usually been active for some time before rickets commences. The frontal and parietal eminences offer resistance, and the direction of least resistance is backwards: so that the brain will follow this and push out the skull at the sides. The

disease supervenes perhaps at one year, and then the interfrontal suture will be ossified, and this the brain again will go backwards and produce a long posterior segment. It will also widen out the parietal eminences and occasion a small and square forehead. If rickets commences early, the posterior fontanelle may remain open as well as the anterior; and, if the brain is large or contains excess of fluid, the sutures may be wide.

Fontanelle Phenomena.- The condition of the anterior fontanelle is of importance in the recognition of rickets, its closure being delayed in that disease. It normally closes at eighteen months or so; but in rickets it may be found open up to the age of two and a half years. I have even knowledge of cases in which it was patent at the end of four years. A systolic murmur may be heard over the anterior fontanelle; it originates in the cerebral vessels and is conducted better by the unossified membrane than by the bones of the head. The posterior fontanelle may also be found patent in early cases.

Grooves.- These must not be mistaken for open sutures; they are the result of pressure from enlarged veins coursing in the scalp and are sometimes very conspicuous.

Craniotabes.- This condition was first described by Elsässer, and consists of small areas, from a quarter to an inch in diameter, of thinned bone upon the occipital or parietal region, close to the parieto-occipital suture. They usually appear about the third month and may be seen up to the eleventh - rarely after the latter period unless rickets is of late development. On pressing on these patches with the tips of the fingers, a bulging or crackling sensation is elicited, the impression given being that of a thick parchment. The frequency of the condition may be estimated at about thirty per cent.; and it is, according to Still (loc.cit.) associated with laryngismus stridulus and tetany, he finding it present in seven out of twenty-one cases of the former disease. Several authors recognise an association of craniotabes with congenital syphilis. Lees and Barlow (loc.cit.) found the latter present in forty-seven per cent. of the cases. Carpenter (Syphilis of Children in Every Day Practice) has found craniotabes mostly in the parietal bones (sixty per cent.), less often in the occipital (thirty per cent.), and least in the frontal bones and there never alone. He regards it as syphilitic, though perhaps masked by the rachitic disease. During a series of observations he found it most commonly during the second or third or fourth months of infant life, seldom after the ninth. Cautley's observations are much to the same effect, though he does not consider it due to syphilis but to artificial feeding, etc., leading to perverted nutrition. Comby does not recognise syphilis in its production, but attaches great importance etiologically to improper dieting. Rasum (Rous. Vratch, iii, 5) has conducted extensive histological examinations, and he concludes that there are two kinds of craniotabes, viz., the rachitic and the non-rachitic. The former, he says, is occasioned by pressure of the brain in lime-salt-short bones, the latter by atrophy or lack of development of the bones. Spietschka (Jahr. f. Kinderh., lix, H.3) has found craniotabes frequently present in newborn infants, the condition, in the absence of proper feeding often becoming truly rachitic; he considers, therefore,

rickets very often is a congenital disease, which from birth he successfully treats with phosphorus and cod-liver oil. My own idea is that craniotabes is an evidence of perverted nutrition, and may or may not be syphilitic in origin, and not infrequently of direct rachitic production.

Facial Phenomena.- The face of the rachitic infant is much smaller than normal, and in severe cases it has a wizened appearance. The alveolar border of the upper jaw is somewhat beak-like, while the lower maxilla is inclined to be polygonal, with some inversion of its anterior surface. The incisors may be in a straight line, the bone exhibiting backward bending at the situation of the canine teeth; this condition, according to Fleischmann, is due to imperfect growth of the middle portion of the bone. Baginsky says that sometimes there is a want of symmetry between the two halves of the bone, so that one side is higher than the other. Eruption of the permanent teeth may be irregular order or be delayed by the rotation of the lower jaw horixontally. The arch of the palate may be distorted. The nasal fossae may be narrowed and the tonsils pushed towards the middle line, with the production of various catarrhs in the locality and perhaps adenoids.

Dental Anomalies.- Dentition is delayed or arrested or irregular when the bones are affected to the above-described extent. The erupted teeth tend to undergo early decay. In the rare cases in which the affection does not occur until after the second year the teeth, if they are all cut before the incipience of rickets, may be quite normal.

THE THORAX.

The osseous thoracic deformities in rickets are of great interest and importance; but in order to understand them, it is necessary to remember the normal respiratory mechanism. The act of inspiration is due to muscular action, and during inspiration the intrapulmonary pressure is reduced and air enters the lungs. The capacity of the chest is increased, its vertical diameter by descent and contraction of the diaphragm. Elevation and outward rotation of the ribs increase the transverse diameter, while the anteroposterior one is increased by a movement upwards and outwards of the ribs, costal cartilages and sternum. The muscles of inspiration, then, are the diaphragm, the external intercostals,- which elevate all the ribs except the first,- the intercartilaginous portions of the internal intercostals, the scalenus anticus, the serratus posticus superior and the levatores costarum. Thoracic expansion in infants is mostly diaphragmatic and abdominal, and the act of expiration passive. On the cessation of inspiration the distended lung partially ceases on account of its elasticity, and in so doing draws in the thoracic wall which, owing to its elasticity, tends to return to the condition obtaining prior to inspiration. The action of gravity on the thoracic wall and retraction of the muscles of the belly assist. The pressure of the inspired air is not sufficient normally to bring about equilibrium to the pressure of the outside air on the chest wall. This is proved in such affections as pneumothorax, in which air enters the pleural cavity and causes collapse of the lung or prevents its complete expansion, as in cases in which adhesions have prevented complete collapse. In health

the thoracic wall,however,resists the atmospheric pressure and establishes an equilibrium.In rickets both muscles and bones are weakened and the chest wall does not offer sufficient resistance;it falls in,therefore,at its weakest and least supported parts.At the junction of the ribs with the costal cartilages there is falling in of the ribs;the cartilagesand sternum are thus thrust forwards,forming a rounded protuberance.Broad and shallow grooves ate thus formed,on either side of the breast bone,running from the second or third rib to the hypochondrium.The floor of the depression is formed by the ribs outside their junction with the cartilages;and along the inner side of the groove the swollen ends of the ribs can be seen - the so-called beading which constitutes the rickety rosary.The latter is perhaps the most constant symptom of the disease.These bead-like swellings are,at the chondral junction,most marked on the fifth,sixth and seventh ribs.The beading is sometimes obscured by the fact that the ribs are displaced backwards at their junction with the cartilage.No trace of this rosary is seen in adult life,and it is seldom seen evenwhen the child is only five years of age.During inspiration the thoracic grooves are sucked in;and,if there is obstruction,as from bronchitis,to the air entering the lungs,this indrawing is aggravated through the lungs being less supported and less distended.Another well-marked sign of rickets is what is termed Harrison's sulcus;it runs acrosss the chest from the lower end of the sternum on either side towards the posterior border of the axilla.In severe cases it may be seen to become deeper during inspiration,and it is always more pronounced in those patients who have suffered from bronchitis or bronchopneumonia.Jenner says that this groove is not due to traction of the diaphragm,but to atmospheric pressure aided by the position of the upper margin of the liver,stomach and spleen.Harrison's groove is about two inches in width and is sometimes called the rachitic girdle.The deformity in question is occasioned by the enfeeblement of inspiration in the presence of incomplete expansion,by the softening of the ribs,and by the atony of the abdominal muscles.One may sometimes observe another groove,of vertical position and outside the nipple line on each side of the chest;it may be alongside or behind the rickety rosary where the ribs and cartilages unite.Its direction is outwards and obliquely downwards over the front of the chest;and is,according to Jenner, due to softening of the ribs.In front of the rickety rosary a slight groove is sometimes observed.From the third to the ninth rib there may be flattening of the chest.The upper ribs are stronger and more strongly supported and covered by thick muscles;consequently,there is no appreciable flattening here.The thorax in the upper part appears contracted because the collar bones are shortened and the shoulders approximated;but in reality its capacity is not diminished. The sternum, owing to backward displacement of the ribs and forward convexity of the costal cartilages,tends to project in front,so that a horizontal outline,taken by a cytometer tracing through the sterno-xiphoid articulation,may be compared to that the outline of a violin.The condition induced is that of"pigeon-breast",which is different to that seen in various infantile respiratory affections.

In rickets there is greater angularity, and the breast of a bird may be simulated by the prominent prjection of the bone. In this disease we sometimes come across what is termed the funnel chest, in which there is a deep hollow, from one to two inches in depth, over the middle of the ensiform cartilage.

CLAVICLES.

The normal curves of the collar bones are sometimes increased; in severe cases of rickets there may be observed at the function of the inner and middle third an acute forward and upward kink or bend, causing distorsion of the bone. In this situation there may be evidences of greenstick fracture appreciable at the inner end, or the middle third. The articular end may show signs of enlargement. Chance examined six hundred cases and found distorsion of the collar bones in only one hundred and twenty. The deformities observed are due to softening rendering them unable to withstand continuous pressure.

SCAPULAE.

These bones undergo thickening in rickets, especially at the lower border. They may be rounded in front and have exaggeration of normal concavity. The shape may ne so much altered that the patient's shoulder-movement is impeded.

SPINE.

The spine in the dorsal region becomes more rounded than normal, kyphosis being induced. In the cervical part the normal curve is increased and the head tends to fall back upon the shoulders. This explains the peculiar attitude of the child. If the patient bends forwards, the weight of the head and shoulders increases the dorsal curve and gives rise to dorsal and lumbar kyphosis. Sometimes scoliosis is present. If the infant sits on the nurse's right arm, the trunk curves to the left side; if on the left arm the curving is to the right. Kyphoscoliosis may compress the lung and give rise to collapse of the organ. The back-rounding and lateral curvature may be appreciated by placing the patient in the prone position and employing gentle traction on the legs. A permanence of the dorsal convexity may in certain cases be observed. The alterations are due to the softening of the bones; and if the patient walks there is dorsal kyphosis, with lumbar compensatory curvation. The cervical bending may be so great that the patient looks upwards. It is very important not to mistake these conditions for vertebral caries or Pott's disease. In rickets there is more rounding and also an absence of tubercular angularity. Again, if the patient be laid on a table face downwards and lifted up by the legs, rachitic curvature will be straightened out, but this cannot be done in Pott's disease. The age of the patient, according to Holt, is of importance; if the patiat is under three years of age, rickets is most likely the cause of the deformity. The previous history of the case must be investigated, with special reference to the condition of the muscular system. Still, it is possible for spinal caries and rachitic vertebral disease to exist simultaneously, as Wyncoop(Arch.Ped., 1905) and other have shown. Rachitic patients sometimes complain of spinal pain, and on this account also great care must be taken over the diagnosis. Ewart(Brit.Jour.Childr.Dis., ii, 157) dwells on the exaggerated flexibility of the spine in rickets. In doubtful cases the nasopharynx should be searches for the presence of adenoids, to which Clarke(Rep.Soc.Dis.of Childr., iv.17) attaches great important from actual observation.

PELVIS.

It is not always easy to detect the pelvic deformities of rickets,as the bones are not easily felt in children of tender age.The anomalies induced will depend upon the age of the patient at the incipience of the disease and the degree to which ossification has advanced.There may be arrest of development and distorsion. The pelvic bones undergo softening and are subject to pressure and muscular action.The deformity will be influenced also by the position of the child and its ability to walk or otherwise.There are a number of pelvic anomalies with an important bearing upon the future career of the child.One of the best-known is the flat pelvis,in which the iliac fossae are flatter than normal and of forward inclination.This variety of pelvis is not infrequently contracted as well,on account of the arrested development.Softening of the bones is not marked.It is best seen in the sacrum,where it gives rise to the kidney-shaped brim.The sacrum sinks between the ilia and its promintory is rotated forwards.The pubic arch is widened;and,in comparison with the normal pelvis,the relative size of the transverse diameter at the brim, and of the distance between the tuber ischii,is increased,-the general effect of all this being to give rise to a shallow pelvis.This form of pelvis is produced before the child can walk:hence the relative widening of the cavity,especially at the outlet,counterpressure at the acetabula having little influence.The weight of the body in the sitting position,plus the counterpressure of the tuber ischii,occasions the widening.There is a diminution in all the diameters of the generally contracted pelvis,though there is no change in their relative proportions.Occasionally the conjugate diameter is contracted more than the others.The iliac fossae look forwards,but the pelvis is not flattened.This is produced late in childhood after the child has commenced to walk. The tendency to widening and flattening is then counteracted.There is a certain amount of softening of the sacrum and ilia in this variety of deformity.The infantile pelvis may be produced by rickets through arrest of development,though without much softening of the bones. The triradiate or pseudomalacosteon form of rachitic pelvis is produced after the child learns to walk;in it the acetabula are forced inwards and softening of the bones occurs.In the case of the scoliotic oblique pelvis the curve is generally to the right in the dorsal region,to the left in the lumbar part of the spine. Owing to the lateral displacement of the line of the body-weight,that side has to bear most of the weight, with thickening of the bones and muscles.The acetabulum is pushed more on this side,and the symphysis pubis is displaced towards the opposite side.Certain cases show irregular deformities,or pelvic crumpling as it is called.These deformities are important on account of their effect on parturition.According to Chalmers(Phys-Deterior.Rep.,p.240)there has been in Glasgow a great increase in the number of operations for contracted pelvis in the case of women who in childhood required osteotomies.In view od the bone softening which characterises this disease napkins should not be too tightly applied to infants;and in other parts of the body the clothing should be properly adjusted

THE EXTREMITIES.

General Considerations.- The various deformities of the limbs make their appearance when the rachtic infant commences to walk;as this art may be delayed for some time,the shape of the bones should receive careful consideration. When the infant is at rest little curvature of the bones may be observed,but the erect position will usually occasion their prominence.One of the commonest signs of rickets is enlargement of the epiphyses, especially at the lower end of the radius,which same has been present in about sixty per cent.of my cases.It is not apparent to the naked eye before the third month. By the tenth or twelfth month it is usually at its maximum,and it may often be detected as late as puberty. This thickening is also commonly observed at the lower end of the femur and tibia.The shafts of the long bones become bent,the actual degree of curvature having relation to the age of the patient,i.e.,the time it commences to walk.The characteristic attitude of a rachitic child is a semisquatting one,the lower limbs being crossed,the body inclined forwards,and part of the weight of the head and body supported by the palms placed flat on the bed or floor.In this way there is a bending outwards of the bones of the arms.The gait of the child is usually waddling,reminding one of a duck.The presence of pseudohypertrophic parlaysis may be suggested in the case of fat and heavy patients with big calves and lordosis.But in rickets there is no abolition of the knee-jerks,and there is no pathognomonic method of getting up from the floor as seen in the former disease.According to Jenner,all rachitic bones are shorter than normal, especially those of the pelvis and lower limbs.The line of pressure will largely determine the nature of the deformities induced.In the case of the legs there is an outward and forward curve in the case of the femur,which is exaggerated if the patient has commenced to walk before the onset of the disease.The tibia shows a similar deformity,which may be unequal in the two limbs;or there may be knock-knee on one side and bowleg on the other. It may happen that the tibia is bent backwards at the junction of the upper epiphysis with the shaft.A sabre-blade tibia is sometimes observed.Bowleg is much more common in young children than knock-knee,owing to the natural roll of the gait at this age.The lower third of the tibia may sometimes show a kink.The inner condyle of the femur may show a bony outgrowth or tubercle. Rachitic children not infrequently grow up into dwarfs, owing to the permanent shortening of the bones.Guérin carefully studied the question of dwarfism in rickets and stated that,owing to the constancy of the diminution in length of the bones,given the dimensions of a rachitic bone,he could tell the size of the others.Not infrequently rickety bones fracture.Guersant says that no less than a third of the fractures seen at his hospital in Paris were due to rickets.Sometimes more than one bone breaks.A large callus is usually formed on the concavity of the broken bone.The deformities may last for life,but usually under proper treatment they can be corrected at an early age.In other cases the rachitic dyscrasia affects unfavourably the whole life of the individual and renders him unfit for certain kinds of work;or a condition of ill health may be induced which may or may not lay the foundation for a variety of dangerous affections.Some authorities regard

pain in the limbs as an important sign of rickets,though various others assign it to the coexistence of scurvy. Zanetti(Pediatrics,Sept.,1904)holds that all rachitic children suffer pain,which may be so severe that the patient lies in a flaccid condition,the slightest touch giving rise to acute agony.This pain,he says,is confined to the bones and does not vary in proportion to the severity of the disease.Colman(Practit.,Oct.,1905),on the other hand,affirms that pain in the limbs in the case of a rachitic patient certainly leads to the probability of the presence of scurvy.

The Humerus.- This bone may be curved at the insertion of the deltoid muscle by the weight of the forearm and hand when the arm is raised.It may have a concavity forwards and inwards,or the concavity may have a backward and outward inclination.

The Radius and Ulna.- These bones have usually a concavity directed towards the palm,the convexity looking towards the back of the hand;they may be also twisted.The deformities in question are produced when the child crawls on all fours,the arms assisting the spine to support the weight of the body.As stated,an early sign of rickets is enlargement of the epiphyses at the lower end of these bones;this enlargement is conspicuous at the wrist,where it forms a sort of bracelet at the radiocarpal articulation.

The Phalanges.- Neurath(Wien.klin.Woch.,1903)has described a thickening of the middle of the shaft of the fingers,giving rise to a spindle-like appearance from,he says,an infiltration of the periosteum.It is said to be best appreciated during the first year and to be pathognomonic of the disease.It has sometimes been called the spindle-hand,and its outline resembles a string of pearls. To detect it,the hand should be examined in profile,when the enlargement in question will be seen to be on the back of the fingers and to stretch the overlying skin. The same author has more rarely seen a rachitic condition in which the proximal and middle phalanges are conical,the terminal phalanx being enlarged like a drumstick or ninepin.Obviously,the condition must not be mistaken for a similar anomaly seen in congenital syphilis. But in the latter disease the end of the finger is like a truncated cone,whereas in rickets the whole finger is affected by a fusiform swelling.Further,there is a therapeutic test available.I have sometimes noticed these conditions,but only in severe cases of rickets.Tubercular dactylitis must also be eliminated from the diagnosis, The anomaly known as Koplik's hand consists of a bowing and thickening of the fingers,which seem longer and more tapering than normal.It is due to thickening of the bones and not to alteration in the overlying soft parts,the lengthening arising from the laxity of the ligaments induced by the disease.The condition is apt to be mistaken for congenital syphilis by the inexperienced.

The Femur.- Deformities on this and the other bones of the lower extremity will depend on whether or not the child has commenced to walk.If the art of progression has been initiated,the natural curve of the femur is increased forwards and outwardsThe head of the bone may be at an angle with the shaft;if the child cannot walk, the shaft will be directed forwards,and for the reason that,as he sits on the nurse's lap,the weight of the leg drags on the lower part of the thigs.The condition of femur-being may be one one side,but usually it is on

both.The condition must be distinguished from the congenital disease by the absence of rachitic signs in the latter.

Tibia and Fibula.- A rachitic child,unable to walk, usually sits cross-legged;pressure is exerted on the outside of the ankle,with the result that the concavity of the curvature of the legs is forwards and inwards and the knees far apart.If the patient can walk,the concavity of the tibia and fibula is from without backwards, so that the knees are approximated and an abrupt curve, with the concavity directed forwards and outwards,exists in the lower third of the leg.Sometimes the legs are variously bent,the one inwards and the other outwards perhaps.The infant not walking may present the lower limbs straight,but small;while the upper ones may show deformity.Trousseau held that rachitic deformities always proceeded from below upwards;but this is not the case.Bowlegs is perhaps the commonest deformity seen in the lower limbs.If extreme,there may be a greenstick fracture.Arrest of development obtains here as elsewhere. The head of the tibia may show an outgrowth of bone on the inner side.Other conditions in these parts have already been described at length.

MUSCLES AND LIGAMENTS.

There is a profound muscular affection in rickets. The infant is very weak;and,owing to its flabby muscles, it cannot hold upits head.Spinal muscular and ligamentous weakness causes arching of the back.This asthenia is due to malnutrition and is well seen in the case of the muscles of the arms and legs;if the child has been able to walk,he loses thie art on the occurrence of rickets,and the muscles waste from both malnutrition and disuse,the latter being aggravated by the softening of the bones.All the muscles of the body are weak,especially those of the chest and abdominal walls.From repeated attacks of indigestion the intestines become distended,and in time this gives rise to an atonic condition. This in turn favours further distension,with results presently to be described.In the case of a healthy infant the respiration is mostly abdominal,the abdomen being protuded with each inspiration.In the case of a child with well-marked atony of the abdominal muscles very little protusion of the belly occurs.The lower ribs in normal inspiration are also expanded;but in rickets,instead of expansion,a retraction of the thoracic walls is seen when the diaphragm contracts.This is because the weakened ribs and cartilages yield more readily to atmospheric pressure than to the pressure in the imperfectly expanded lung.Owing to this want of a fixed fulcrum,the diaphragm,already weakened,is hampered in its action on the enlarged abdomen.Expiration is also interfered with,on account of the weakened condition of the belly,and is simply a passive recoil;even the latter is weak through imperfectly performed inspiration.The muscles are pale,flabby,soft and emaciated;under the microscope their striations are blurred or indistinct. The ligaments participate in the general asthenia;they are weak and yield to both traction and pressure.In the case of the spine they yield and allow of the development of the curvatures named.The ligaments govering the articulations also suffer,so that flat-foot,knock-knee,etc.,occur when the infant commences to crawl or walk.

CUTANEOUS SYSTEM.

The skin of a rachitic child is usually possessed of a marked pallor and is flabby. Not infrequently there is an abnormal amount of fat, so that the patients seems uncommonly plump for its age; sometimes, however, there is great emaciation, especially if syphilis is also present. Perspiration, especially of the head, is a very early symptom; it is usually seen at night and may be so intense as to soak the pillow. Some writers recognise in this head-sweating some connection with the hyperplastic changes in the cranial bones, whereas others hold that it is due to the action of some irritant on the glandular components of the skin or some reflex nervous irritability. The veins of the scalp are markedly enlarged, and by their pressure form grooves in the softened cranial bones. Some of the cases do not present any signs of head-sweating, so that it is not a pathognomic symptom as has been alleged. The sweating gives rise to various sudamina, which vary in size from a slight exanthem to a papular efflorescence. The body and limbs may show eruptions of this kind; and I have often noticed that they are difficult to cure, owing to their dependence on the general perversion of nutrition induced by the disease. Impetigo sometimes occurs, and the same and other rashes may erroneously be assigned to dentition. The hair of the rachitic infant is not infrequently dry and dull, thin and of a poor variety. The glands of the skin may undergo enlargement, with the development of boils, particularly if the itchy lesions be much scratched and infected. Hyperaesthetic conditions have been reported, but are probably due to some other disease than rickets.

NERVOUS SYSTEM.

The nervous system is inclined to be severely affected in rickets, and from the very onset of the disease. The infant so affected is restless and fretful, which fact, however, may not infrequently be assigned to the gastrointestinal catarrh induced by improper feeding. Several writers dwell on what they consider increased mental development as indicated by the enlarged rachitic head. Trousseau (loc.cit.) states that these " little suffering creatures, who are unable to walk about without assistance, generally possess a greater intelligence than other children of the same age. Their physiognomy, so often stamped with sadness and suffering, their expression of countenance, their way of speaking, all denote an advanced development of the intellectual faculties". Thackeray has been cited as an example of this precocity. Jenner (Med. Times & Gaz., May 12, 1860) wrote against this view. "Children", he says, "the subject of extreme rickets, are almost always deficient in intellectual capacity and power. They are not idiots; they show no signs of idiocy; they resemble rather children of low intellectual capacity and power much younger than themselves". He ascribed the error to the fact that rickety patients, removed from the companionship of other children by reason of their physical defects, would be much of their time in the society of adults, and would "catch their tricks of expression, their phases, and even some, perhaps, of their ideas". My own observations would seem to confirm this view. According to Smith (Wasting Diseases of Infants and Children), "apart from all physical changes, the behaviour of a rickety child is very characteristic, and is of itself almost sufficient to warrant a

diagnosis.The quiet,the repose about him strike the observer at once.Such a child,if able to support himself, will sit for hours,his legs stretched out straight before him on the floor,perfectly contented if only allowed to remain unnoticed.All that he wants is to be left alone.A healthy child delights in movements;a rickety child is only happy when at rest;his greatest pleasure consists in inaction.To look at him we are irresistibly reminded of the other term of life,for he appears to have anticipated at least one consequence of the weight of years,and to have combined the patient endurance of old age with the face and figure of a child."Rittershain has measured a number of rachitic skulls and says that the cranium is no larger than in healthy infants of the same age.Lucas(Brit.Jour.Childr.Dis.,i,341)thinks that rickety children are more clever than normal ones,though he is apparently at a loss to account for this.The rachitic infant is late in learning to talk,the sixteenth month being passed perhaps without an effort being made. Warner(The Study of Children,p.233)denies the alleged precocity of the rickety child,having found them delicate,stunted,and mostly dull.I have noticed that children who have in early life suffered from rickets are somewhat more backward than others.Shuttleworth(Brit.Med. Jour.,Oct.3,1903)confirms this,and says that he has seen the poorer children suffer from much hebetude from general malnutrition,some of the cases being even feebleminded;amongst the children of the wealthier classes abnormal mental development may occur.Bourneville has given close attention to the question and considers rickety children of weak mind.Renoult(Thèse de Paris, 1903)holds that rickets is not the cause of weakmindedness,but that the latter and the former may be produced by various infective processes of early age.

Rickety infants very frequently take convulsions; and,in the opinion of some,the disease is responsible for all such occurring during the first year of a child-'s life.The nervous system in a rachitic infant being in an unstable condition,some such trivial cause as teething,overloaded stomach or colon,and dietetic errors may bring on an attack.In short,rickets is the most potent cause of the fatal or non-fatal spasmodic attacks of infants.Taylor(Nervous Diseases in Childhood and Early Life)says that most convulsive attacks at this period are of such origination,owing to the lack of coordination between the development of the nervous tissue and the enveloping connective material,irritability of the cells being thereby occasioned.He goes on to inform that under ordinary circumstances the higher centres of the nervous system govern the action of the lower ones,which latter,if uncontrolled,have a certain inherent automatic action leading to discharge,when unbridled,in the form of convulsions.Again,incomplete development of the higher centres deprives the lower ones of their salutary control,with resulting discharges in convulsive form.Our author therefore recognises two kinds of convulsions,the higher-level and the lowerlevel,which may be produced by irritation of any kind, particularly such as exists in rickets,which latter, too,may have an etiological bearing upon epilepsy in adolescence.The convulsive attacks may assume various forms,such as laryngismus stridulus,tetany and general spasms.There is some difference of opinion regarding

the frequency of these conditions,and for the reason that the onset of the rachitic disease is not infrequently not determined with accuracy.Divine(Brit.Jour. Chil.Dis.,iii,448)has investigated the mortality of convulsions in infants to the following effect;the year 1903 being concerned:

	Percentage of Deaths		
	Months	Months	Months
Cause of Death	0 - 3	3 - 6	6 - 12
Convulsions	62.0	20.9	17.1
Rickets Group	3.7	17.2	79.1

He does not take into consideration the first three months of infantile existence,when congenital conditions and dietetic errors are responsible for the deaths.From three to six months he recognises rickets in its incipience;but from six months onwards rickets is held to be responsible for the vast majority of the convulsive attacks which occur.These he regards as vastly underestimated.Thomson(loc.cit.)regards rickets as the most prolific cause of convulsive seizures in infants,and says that proper anticipatory treatment will prevent their occurrence.He finds the condition most common from six months to two years,especially during the cold windy months of the spring.In view of the history of the case and the special rachitic expressions,he holds that there should be no difficulty in diagnosis,and also that it is unnecessary to administer sedatives for relief.But such a recognised authority as Cautley(Clin.Jour.,xxvi) insists that,though rickets often gives rise to convulsions,it has been assigned far too much importance in this respect.It is the dietetic errors responsible for rickets in which he believes,especially as comparatively few rachitic infants become convulsed and rickets is practically ubiquitous.Holt(loc.cit.)thinks that rickets predisposes the convulsions by inducing perverted cerebral nutrition.Despite difference of opinion on various points,there can be no doubt that convulsions occur most usually from the age of three to six months, during which time it is more fatal than otherwise.Most of my cases have been during the first six months.But rickets usually occurs between the seventh and eighteenth months:so that,if it is a predisposing cause,it is not the only one.Still,rickets is a powerful predisposing cause of the spasms of early life,and a large proportion of cases severely affected by the disease are affected in this way.There seems a great tendency on the part of practitioners to assign convulsions during the time of teething to dentition,which is a mistaken idea as so very many attacks are seen before the teeth commence to cut the gums when rickets is present to some extent and manifestly responsible for the phenomena observed.Dentition,gastronintestinal affections,etc., predispose to the attacks,and to such predisposition that of rickets may be added;then the seizures will be much more severe and dangerous.It is generally agreed that in rickets the nervous system is in a very badly nourished condition.In addition to the increased reflex excitability induced there must be taken into consideration various changes occurring in the body leading to delayed development of the proper functions of the inhibitory or controlling centres of the central nervous system.Then trivial causes,such as constipation,diarrhoea,dentition,or various rachitic stimulations may excite violent convulsions - the latter being also

predisposed to by the compressions of the cranial contents by the softened skull bones and the imperfectly oxygenated blood supply of the brain. Convulsions in rachitic children are of serious import; they may even be the cause of epilepsy in later life; the urgent necessity for their prevention is obvious.

Laryngismus stridulus is perhaps the most common form of convulsions seen in rickety individuals. Elsasser says that craniotabes is associated with the accident, but others deny this. It may, however, be associated with general convulsions and tetany. He accounts for its frequent occurrence in the nocturnal hours by pressure of the thinned occiput on the pillow, and adds that it can be produced by pressing on a craniotabic patch on this bone. Jacobi (Therapeutics of Infancy, p.143) Holds that the condition is in the vast majority of instances a rachitic expression of meningeal or cerebral origination. Eustace Smith (loc.cit.) denies that there is an exciting central irritation; he prefers to regard it as a reflex neurosis consequent on peripheral irritation existing in rickets and stimulating the irritable nervous tissue. Gee found rickets present in forty-eight out of fifty cases; and he observed the attacks mostly in males from the sixth to the eighteenth month. The laryngeal spasm consists of a sudden arrest of respiration, - this reflex spasm being excited by such slight irritations as a breath of cold air, crying, laughter, fright, anger, a tickling sensation in the pharynx, excitement or emotion, - lasting for a few seconds and ending with a crowing inspiration due to air being drawn in through the narrowed glottis. The attacks are usually observed at nighttime, though, according to some, laryngismus is quite as likely to occur during the day as at night. In most of my cases, however, the attack has occurred when the child has been asleep. During the day the rachitic patient has perhaps been rather indisposed, had a tendency to cough, or has manifested some slight catarrh of the throat or bronchial tubes. At midnight, or later, the child awakes with a crowing or whistling inspiration. It starts up in bed, and apparently experiences great difficulty in breathing; this difficulty is manifestly in inspiration, expiration being easy and free. The eyes are prominent, the lips blue, the skin not infrequently bathed in perspiration; the pulse is accelerated, small, at times irregular; there is, if the child be old enough to reason in the matter, great alarm; there is not infrequently cough which is more or less characteristic, it being hoarse, metallic, barking, and croupy. If the spasm is limited to the larynx, the other muscles not being affected, the patient clutches at whatever it can reach, and it often seizes the throat as though there was something there to tear away. The skin becomes cyanotic and all the symptoms of suffocation are present. The voice, though not generally quieted, is altered: it becomes hoarse or husky. In a few minutes the severity of the attack is passed and the patient sinks into a more or less disturbed slumber. A second attack may occur the same night, or there may be nothing more to alarm the mother until the following evening. The second attack, if it occurs, as it generally does the next night, is usually less severe than the first; the third is still more mild, and this generally ends the case for the time being. During the intervals, i.e., during the day, the patient in the vast majority of instances seems little the

worse for the night's experience.There will perhaps be a slight cough,with some indisposition and less inclination to engage in its usual amusements.This is the type of the affection that I have most often observed.In some cases I have seen a more marked derangement of the general health.The spasms are more severe;the cramp is not confined to the laryngeal muscles,but involves other parts,such as the muscles of the thorax and limbs.During the intervals of the attack there is perhaps a little pyrexia,the digestive tract is somewhat disordered,the cough may be more marked during the day,and there may be an increase of the bronchial catarrh present in these cases.Attacks may take place during the day for several days,the cough may continue to be croupy and a hoarseness of the voice may be observed.In the vast majority of my cases the laryngeal spasm has been of a transient nature;it has lasted from a few seconds in the milder ones to several minutes in the graver forms of the disease.The spasms are intermittent,and they are relieved at intervals by comparative relaxation of the muscles of the parts.Even in the intervals there is,however,a certain amount of contraction of the constrictors of the larynx,so that relief is not absolute.Two or three days elapse before the attack may be regarded as quite over. In the severer forms I have seen the effects of the laryngismus continue for a still longer period.I have seldom observed an definite sequels.When the child has recovered there is no further disease of the kind,only perhaps a tendency to recurrence,another attack being excited by the factors already mentioned.As long as the underlying rickets is present there is always a risk of return.The condition must be distinguished from true croup,and according to the usual means.The prognosis is, on the whole,favourable,the vast majority of cases recovering.The child seldom dies from laryngismus stridulus unless there is some complicating or coincident disease.Pulmonary collapse,in particular,is apt to be aggravated by the spasms and cause the death of the patient.

Tetany is sometimes observed in connection with rickets;in it there is a tonic spasm of the muscles of the limbs;the calf seems hard and the foot points;the wrist is pronated and flexed and there is spasmodic contraction of the interosseous muscles.This functional carpopedal spasm may commence abruptly with spasmodic jerkings of the limbs,though usually we observe certain prodromes in the form of prickling,numbness and sensations of heaviness in the arms and legs,after which the muscular phenomena develop.The thumb is adducted into the palm,the fingers flexed at the metacarpophalangeal joints and extended at the other articulations,producing the condition known as the accoucheur's hand.This form of contraction is,however,not always present,the fingers being sometimes,with the thumbs,tightly flexed.The wrist is flexed upon the forearm and the latter flexed somewhat upon the arm.The upper arms are generally held tightly to the trunk.The thighs and knees are extended, the toes flexed and the foot is inverted.The contractions are tonic and the muscles are hard.Some pain may be experienced during the muscular contractions,though by no means always.In mild cases the spasms affect only the arms,and possibly the legs.It is usually associated with laryngismus stridulus.In severe cases the trunk muscles may be involved and a condition of opisthotonos

induced.In the worst cases the whole body may become rigid as in tetanus;even the muscles of the face may become contracted and the patient then presents a tetanic appearance.But lockjaw is rare and occurs only late in the course of the affection.The attacks last from a few minutes to several hours,or even for many days.They are not accompanied by a rise of temperature or any serious systemic effects.The attacks may subside for several days or weeks and then return.In rare instances the affection may manifest itself for months or years,though the usual duration does not exceed a few weeks.There is some risk of epilepsy being excited.Oedema of the hands and feet,due to venous obstruction,is sometimes seen in tetany.Many of these cases have been referred to dilatation of the stomach from fermenting starchy material. There are certain useful signs worth remembering for the recognition of the disease.One of these is Trousseau's symptom:the upper extremity is grasped so that the vessels and nerves on the inner side of the limb are firmly compressed,and after a interval of from thirty seconds to two or three minutes the hand presents the characteristic appearance already described.Facial irritability,or Chvostek's symptom is also not infrequently present in this disease,and even,it is said,when there are no other nervous phenomena apparent.It consists of a peculiar irritability of the motor nerves,This is so marked that striking on a motor point brings out a muscular contraction which may remain for several seconds.When the motor point of the facial nerve is struck,a spasm of the muscles of that side of the face is produced,which receives the above name.The masseter muscle is a convenient one for the detection of the sign. It is a symptom of considerable moment,being a clear indication of the nervous irritability of the child.It is,as stated,not infrequently associated with laryngismus;but often it exists alone and is then strongly suggestive of convulsive tendencies.A similar nervous insufficiency may be observed in connection with such other muscles as those of the extremities.Another symptom special to this affection is that called after Erb,the symptom being first described by this well-known neurologist.It consists of an increased electric irritability of the muscles and nerves,especially to the continuous current.A negative-pole contraction is occasioned by a very weak current of a fraction of a milliampère;and,if this current is made stronger,the contraction becomes tonic.The positive-pole opening may also be tonic and there may also be an opening tetanic contraction with the negative pole.Thomas describes a peculiar electrical condition in which the nathode,when placed over the nerve,produced,first,fibrillary and then tonic spasms in the muscles supplied by the nerve;but when the anode was substituted for the cathode,no contraction was obs-erved,even as strong a current as five or seven milliampères giving rise to no spasms.Hoffmann's symptom consists of a peculiar irritability of the sensory nerves,which is appreciable when they are pressed upon, sensations of prickling and formication being experienced along their course.There is an increase also in the electrical sensibility,as can be demonstrated by the application of a very weak continuous current.The sensibility of the nerve of hearing is also abnormally increased.Tetany is,according to Jacobi,in the vast

majority of instances due to rickets, especially when craniotabes, laryngismus and other rachitic phenomena are present. Burnet (Med. Press & Circ., 1905, p.54) allows that the condition may sometimes be due to gastrointestinal anomalies; otherwise it is the outcome of rickets. According to Bouveret and Devin, gastric dilatation and hyperacidity favour the development of the disease. It is important that the affection be not confused with tetanus, which is avoided when we remember that it has not the persistence of serious character and consequences of that affection. The spasms are generally limited to the extremities, and are of moderately short duration; there is no violent or painful opisthotonos or trismus. The spasms in tetany also commences in the limbs and extend up the body. There is no lockjaw, and seldom are the muscles of the face and cervical region involved. The diagnosis will be confirmed by noting the absence of trauma or a wound, and also the presence of the special signs described. The progmosis is favourable in the vast majority of instances.

The evolution of rickets is sometimes associated with the phenomenon known as head-rolling or nodding or spasmus nutans, which may or may not be accompanied by nystagmus. It is an indication of the unstable condition of the nervous system and is apt to occur early in the course of the disease. The child rolls its head from side to side, so that on the back of the skull the hair is thinned by friction on the pillow. It ceases when the patient wakes out of sleep. It is usually seen from six to twelve months; and if it is of long duration, some brain trouble may be suspected. Otorrhoea may, according to Burnet (loc.cit.) also be present.

Horner says that rickets may have something to do with the development of zonular or lamellar cataract, which he has observed, as have others, in several instances.

Certain rickety infants have the habit of banging the head against the cot or floor. This head-banging is probably dependent on dentition or other reflex irritations. Osler regards it and head-nodding as a "coordinated tic". Still regards rickets as an occasional cause, but usually dentition or middle-ear disease. Carpenter describes various cerebral lesions in connection with it, showing that sometimes there may be a deep-seated brain alteration at the root of the mischief.

The rachitic condition may give rise to chronic hydrocephalus. In rickets the circulation of the brain is sluggish and there may be hyperaemia of the meninges of the cerebrum. In health the cerebrospinal liquid is controlled by the pressure of the cranial bones, and a uniform pressure on the various structures is maintained. In rickets, when ossification is at fault, there is on removal of the pressure, excess of cerebrospinal exudation. Fluid distends the cerebral ventricles, the brain substance is compressed, the convolutions are flattened out and the bones themselves yield to intracranial pressure - hydrocephalus being produced. The rachitic hydrocephalic head may be of great size, the face in comparison to the skull being remarkably small. The sutures and fontanelles are widely open, and the skin of the head is thin and stretched. The cranial bones are thin and diaphanous. The fluid is in the lateral and third ventricles. The corpus callosum and fornix form an incomplete partition between these, their intercommunication

being via the foramen of Munro.The liquid pushes up the fornix and corpus callosum and drives the septum lucidum forwards,with the result that the three ventricles are converted into a single cavity.The basal ganglia are also compressed,the velum interpositum and choroid plexus being free in the effusion.The grey and white matter are attenuated,there is very little fluid in the subarachnoid space,the veins on the surface of the brain are compressed and possessed of little blood.The liquid may also distend the fourth ventricle via the usual communication of this with the brain above.The patient's head is rounded or globular,and in some cases it is so large that it cannot be raised from the pillow.On its surface numerous distended veins are observed.The accident is usually observed in rachitic cases before the fifth month or sometimes up to the eighteenth;it may be congenital,and,of course,should the head be ossified prior to its incipience,there will be no enlargement of the cranium.It is variously initiated:the gradual enlargement of the head may be the first thing observed,or the malady may commence with symptoms of irritability and fretfulness,or of strabismus or convulsions,before any increase in the size of the head can be made out. The orbital plates of the frontal bones may be displaced,with consequent depression of the eyeballs.Pressure on the optic nerve may occasion neuritis,atrophy or amaurosis.There may ultimately occur increasing mental enfeeblement,loss of memory,convulsions,weakness or paralysis of the extremities,and anomalies of the special-sense organs;and the patient has to keep continually in bed.The appetite in these cases is sometimes unimpaired;sometimes it is lost and great emaciation occurs.Convulsions,coma,marasmus,or some such intercurrent affection as pneumonia or bronchitic may carry off the patient in a few months or years.It may happen also that the patient recovers and lives to adolescence,though with some outcome of the affection in the form of muscular or mental enfeeblement.The attenuation of the cerebral tissue in rachitic hydrocephalic cases is sometimes remarkable in degree.Jenner holds that the condition is in many cases the outcome of rickets,but there are numerous others who deny this.It is usually observed as a complication of the rachitic state,and,as stated, is the outcome of such factors as sluggishness of the cerebral circulation and the severe hyperaemia of the cranial-vault bones and meninges.Nystagmus is a common accompaniment of the disease.

Some rackety children have the habit of swaying the body to and fro whilst sitting;the symptom is called body-rocking and the patient appears as if keeping time to a melody in a pendulum fashion.Very young children who are always lying down do not,of course,present the symptom;it is therefore uncommon before the age of nine months.The movement is generally from side to side,though it may perhaps be from before backwards from the hips as a fulcrum.The attitude adopted is sometimes the so-called pagoda position,the legs being crossed in front and the hands folded as in the statue of Buddha.

RESPIRATORY SYSTEM.

I have already shown to what extent the shape of the thorax is affected by rickets.Respiration is governed by a special centre in the medulla.It is automatic in action,performing its functions independent of

afferent stimuli.Direct stimulation occurs from the access of venous blood.Anything interfering with the respiratory movements,or any obstruction to the pulmonary circulation or even the commonly-present anaemia of this disease,interfering with the normal interchange of gases in the blood and the alveolar air,will produce venous blood,and so give rise to certain effects.In rickets embarrassed respiration is occasioned by the alterations in the thoracic wall and diminished capacity of the chest,leading to deficient blood-aeration.According to severity there may be dyspnoea,hyperpnoea,orthopnoea or asphyxia.In some cases interference with the respiration is marked."This habitual oppression",remarks Trousseau,"is a constant phenomenon in confirmed rickets,particularly when it occurs during the first two years of life.At a later age,that is to say,in children of three years,it is an exceptional phenomenon.In the very young infant,it exists in an extreme degree.Bear in mind that,at a very young age,the disease first appears in the chest,which is the seat of the earliest deformities;while in children who have begun to walk,they are first seen in the lower extremities.Bear in mind the degree to which the thoracic deformities proceed, and the extent to which the play of the respiratory organs is embarrassed.The embarrassment of the respiration,which plays so great a part in the disturbance of nutrition by rendering imperfect the process of haematosis,makes rickety more liable than other children to acute pulmonary affections,bronchial catarrhs,catarrhal pneumonias,which,in consequence of the obstacle to free inspiration occasioned by the thoracic deformity,assume a very great degree of gravity.Pulmonary tuberculosis is a very unusual complication of rickets."The thoracic deformities and weakness of the respiratory muscles predispose to bronchial catarrh,especially in view of the general perversion of nutrition existing.This bronchial catarrh may lead to bronchitis or bronchopneumonia or collapse of the lungs.Enlargement of the tonsils is very frequently present in rickets,and the same,together with nasopharyngeal growths,may further interfere with the entrance of air into the lungs.In the case of bronchitis,the contents of the swollen bronchial tubes will impede the proper circulation of air;the air imprisoned in the alveoli becomes absorbed and the vesicles collapse,particularly at the roots of the lungs and in the middle lobe of the right organ.To supply the deficiency compensatory emphysema occurs,the support of the adjacent lobules being withdrawn.The outcome of this is a loss of capillary area and consequently of aerating pulmonary surface,which will render the respiration still more feeble and inefficient.In rickets there may also be collapse of the lung substance from hyperscoliosis.I have already explained the mechanism of groove-production in the chondro-costal articulation areas, with projection of the breast bone.To fill up this space the air cells are distended during inspiration; emphysema is thereby produced at the anterior edge of the lungs in the part which is least supported.During the intake of air the beadings on the ribs,which project inwards,press on the lung and prevent the lobules from becoming distended;and in this way there is produced a collapse-groove corresponding to the rickety rosary.

In a series of rickety cases Duklesky(Arch.Ped.,1904, p.790)observed a new sign which he terms polypnoea;by the term is meant rapidity of breathing,the respiration being in his observations increased various from fifty-six or eighty to one hundred and eighteen per minute.He says that the symptom is produced by either irritation of the respiratory centre in the medulla by the excessive amount of carbonic acid in the blood,by the diminution in the size of the thorax,or by the hyperexcitability of the central nervous system induced by the disease. All his cases recovered under proper treatment for the exciting dyscrasia.Carbonic acid in the blood is held by Wachsmuth to lead to a chronic intoxication provocative of all the rachitic lesions.Not infrequently the bronchitis or bronchopneumonia of rickets seriously threaten the life of the patient.The respiratory muscles are weak and the ribs softened;the lower ribs are everted,rendering,especially in the presence of the characteristic"pot-belly";the breathing excursions less efficient.A sort of vicious circle is induced thereby. On account of these mechanical defects the lung is imperfectly filled with air,and the collapse thus induced favours the occurrence of bronchitis and further atelectic conditions.The superaddition of catarrh of all the mucous membranes of the body renders the mechanical deficiencies worse.Further,the rachitic child is badly nourished,very often lives amidst unhygienic conditions, and is very liable to the usual dangerous debilitations. Some of the cases closely simulate phthisis,especially when such glands as the thymus are enlarged in addition to the chest lesions;the adenopathy may be the cause of sudden death.These patients are apt to be troubled with asthma or tuberculosis in after-life,and the gastro-intestinal and other catarrhs are sometimes of chronic course.

CIRCULATORY SYSTEM.

Heart.

The rachitic alterations in the shape of the chest not infrequently give rise to circulatory disturbances, these being mainly of a mechanical nature,and aided by the upward pressure of the abdominal viscera.In children the normal position of the apex beat of the heart is in the fourth interspace;but in rickets,owing to the above-mentioned factors,its position undergoes a certain amount of change.The point of the organ is displaced a little outwards towards the left;here,at each beat,the heart comes in contact with the nodule on the rib,where there is produced on the thickened pericardium a whitish friction patch,which is on the left ventricle of the organ a little above the apex.A similar patch is sometimes found in the case of the spleen from friction against a rib nodule during the respiratory excursions. In the heart itself there are no definite microscopical changes,though the organ,of course,shares in the general malnutrition of the system and causes enfeeblement of the circulation.The muscular substance of the heart is badly nourished and its muscle is accordingly weak. When there have been bronchial and other catarrhal chest troubles the right ventricle has more work to perform;and if,as in bronchopneumonia,there is considerable pulmonary obstruction,the right heart may be unable to cope with its task and sudden death result.The right ventricle first dilates and then hypertrophies, with the result that the venous system becomes engorged.

There is produced engorgement of the right auricle,- which itself dilates and hypertrophies,- and of the inferior and superior vena cava;the liver becomes congested,and later on will be found development of oedema of the feet,legs and trunk,together with albuminuria, from renal congestion.The tricuspid valve may become incompetent.Palpitation,tachycardia,or slow and irregular pulsations may be produced by the hampering of the cardiac action by the abdominal distension.

Blood-Vessels.

The various arteries of the body become dilated and the circulation sluggish,with resulting low pressure in the various organs.According to Beneke,the pulmonary artery in rickets is abnormally large,the pulmonary complications of the disease being thereby explained.It may happen that one hears a systolic brúit over the patent anterior fontanelle.Roger(Clinical Researches on Auscultation of the Head,1860)says that,from "its great frequency,cephalic blowing may be regarded as a sign of rickets;"though not a pathognomonic one,Others regard it as of value in distinguishing a rachitic from an ordinary hydrocephalic head,it being common in rickets but rare in hydrocephalus.Though the murmur may be heard up to the fifth or sixth year,it is most commonly noted in the second year;and,according to Osler(Bost.Med.& Surg. Jour.,1880,ciii,No.2,p.29),it is sometimes present in the case of healthy infants.Under normal conditions the circulation of blood and lymph is carried on mainly by cardiac muscular contractions and pressure.In rickets the muscle of the intestines is weak and atonic,as are also the muscles of the abdominal wall.Owing to this loss of muscular power,there is capillary stagnation, and the tissues become bathed in an excess of blood and lymph.Such congestion is seen in all the viscera drained by the branches of the portal vein;they are the inferior and superior vena cava,the splenic and the gastric trunks.That formed by the their union,-the vena portae,- enters the liver and ramifies through its substance;and its branches emerge from the organ as the hepatic veins to join the inferior caval vessel.The excess of liquid in the tissues occasions hyperplasia,and so the liver and spleen become enlarged.Under conditions of heart disease such as described,hyperplasia also occurs in the hepatic tissue.The congestion of the organs will be in proportion to the weakness and atony of the muscles concerned,and in the case of the stomach and intestines a catarrhal condition results.The occasional occurrence of haemorrhoids can be accounted for in this way;the complication would be more common than it is in severe cases,but for the recumbent position necessarily assumed.Constipation or diarrhoea may be present according to the effect of the existing anomalies.

Blood.

Rachitic infants are commonly anaemic and have the curious waxy,greenish-yellow tint which is sometimes seen in the anaemia of young women.But all rachitic children are not anaemic.In such cases as the spleen is markedly enlarged we sometimes find a high grade of anaemia,the so-called splenic anaemia or pseudoleukaemia infantum,which has been regarded by some as due to syphilis,though occasionally observed independent thereof.The blood in rickets has no special characteristics. The number of cells may be about normal,though the

haemoglobin may be decreased to about forty or fifty per cent.The number of leucocytes may be increased from two to five times,and in severe cases some of the red cells may be nucleated.Hutchinson refers to cases in which the examination of the blood gave chlorotic findings.The following results are given by Thursfield and Drysdale:haemoglobin,44%,red corpuscles,4,364,000,white corpuscles,11,000,polymorphonuclears,49.2%,lymphocytes, 46.8%;large mononuclears,3.3%,eosinophiles,.5%,myelocytes,0,and occasional nucleated red blood-corpuscles. The slight increase in the polymorphonuclear cells is practically the only difference from the normal observation in these cases.

DIGESTIVE SYSTEM.

Rickety children are late in cutting their teeth, which are apt to come through the gums in improper order and to undergo early and rapid decay.I have frequently seen these patients toothless at the end of the first year of life.Dentition may be complicated with convulsions.Rachitic teeth are very brittle and poor in enamel,which is sometimes irregularly deposited and of weak construction.These teeth soon decay and break off, the child being left with a mouthful of decomposing stumps from which infection and various troubles lower down the digestive tract are apt to result.A toothless mouth at ten months should raise a suspicion of rickets and the proper treatment for the condition instituted at once.It may happen that the infant cuts one or two teeth prior to the development of rickets,which will lead to arrest of dentition for perhaps several months;this is a useful diagnostic sign.

The tongue in rickets is sometimes coated,but usually only to a slight degree.When there is considerable catarrh of the gastrointestinal tract the organ is more red than normal and not infrequently sore,especially at the tip and edges,where small papules may sometimes be observed;these may break down and ulcerate.On the dorsum of the organ there may be seen little islands, red,marginated and deprived of epithelium.These increase in size and number and extend backwards tothe root of the tongue,often healing upand then reappearing. Parrot considered this condition syphilitic in every instance,but this sweeping theory has since been disproved.These islands correspond exactly with the erosions seen near the solitary glands and those of Lieberkühn in the intestines,which mean nothing more than incompetence of absorption in that locality and abnormal secretion.The name"geographical tongue"has been coined to designate the condition.

Rickets is one of the affections in which hypertrophy of the tonsils and adenoids are very common.Some hold that they are due to lack of exercise,but it would appear that they are part of the general hyperplasia of the connective tissue of all the glandular structures of the body.If the fibrous tissue component preponderates,the tonsils are almost as hard as a fibroma.These enlarged structures may interfere with swallowing,as well as with the free entrance of air into the windpipe; and they and their associated nasopharyngeal growths and catarrh are sufficient to give rise to deformity of the chest in the form of pigeon-breast.In every instance surgical measures should therefore be employed. Deafness not infrequently occurs from obstruction of

the Eustachian tubes;and children with enlarged tonsils are more apt than others to contract infectious diseases,such as scarlatina and diphtheria,which not infrequently prove fatal.Mouth-breathing,snoring and nasal voice are common and characteristic phenomena;and the widely open mouth gives these patients a characteristic physiognomy.At puberty these enlarged structures tend to take their departure;meanwhile they can sometimes be reduced by various astringents,but it is better in all cases to effect their removal by one or other of the simple and safe operations devised.

The well-known"pot-belly"of rickets is very characteristic,and is induced by weakness of the abdominal muscles,to flatulence causing distension of the stomach and intestines,partly to downward displacement of the lover and spleen by the thoracic anomalies,and to diminution of the size of the pelvic cavity.The abdominal enlargement not infrequently gives rise to separation of the recti muscles,and in certain cases this may be as much as an inch.Many of the cases are markedly constipated,though at times severe diarrhoea and straining may change the scene.The stools are not infrequently of a greenish colour and mixed with a whitish and curdy material,consisting mainly of undigested milk;they are apt to be very offensive.The food apparently passes through the alimentary canal mostly unchanged,being propelled too quickly for digestion,owing to intestinal hyperperistalsis.The bowels are apt to participate in the general catarrh of the mucous membranes and diarrhoea to constitute a marked feature of the disease.Piles are occasionally seen.In these cases the LIVER is apt to be displaced downwards or enlarged or both displaced and enlarged. The displacement is due to the thoracic deformity;the enlargement results from chronic hyperaemic fibrosis occasioned by the pulmonary obstruction and enfeebled heart,or perhaps by congenital syphilis or a circulating toxin,in which case there is usually also a considerable enlargement of the spleen and possibly of the lymphatic glands of the body.Concomitant hyperpastic enlargement may be seen sometimes in the mesenteric glands,and jaundice is now and then observed.The SPLEEN may be enlarged also,and its margin palpable an inch or so below the ribs.Sometimes its lower border reaches as low as the umbilicus or a trifle below it, usually from syphilitic mischief or acute splenic anaemia,though sometimes from ordinary fibrosis or hyperplasia.Küttner noted enlargement of the organ in forty-four out of sixty cases;in thirty-three it could just be felt,in nine it was about an inch below the ribs, and in two there was great hypertrophy.

URINARY SYSTEM.

There are no characteristic urinary changes in this disease.The urine voided is general of a pale-straw colour,and there is sometimes,especially in the presence of gastrointestinal catarrh,increase in the amount of earthy phosphates.Fagge(Trans.Path.Soc.,xxxii)describes increase of uric acid,whereas others have noted diminution of this and of the urea passed.Excess of oxalate of lime and phosphate of calcium,and the presence of free phosphoric and lactic acid have also been reported in rickety children.The odour of the urine may be strong;and,according to Carmichael(Dis.Childr.,p. 177),increased frequency of micturition is an early

diagnostic sign of the disease, due to the irritability induced by the catarrh of the bladder sometimes present.

EYES.

Rachitic children are sometimes brought for treatment of such ocular affections as cataract, which may be of the zonular or lamellar variety. The condition is apt to make its appearance during the period of dentition, though some have affirmed that these children are born with it. It is one of the partial or stationary cataracts which is apt to affect botheyes, and is the most common form of the condition seen in children. It is not infrequently associated with convulsions and marked rachitic changes in the teeth and bones. It consists of a gray, disc-like opacity of the layer surrounding the transparent nucleus, with clear cortex on the outside. When the pupil is dilated, examination by oblique illumination shows a grayish disc surrounded by clear lens substance; from the margin of the opacity short striae are often seen projecting into the surrounding transparent cortex. The cataract is most dense at the margin of the disc; this distinguishes it from nuclear cataract. By the use of the ophthalmoscope at a distance, the cataract presents a dark disc surrounded by a zone of red fundus-reflex; the disc is somewhat lighter in the centre than at the periphery, and in the former situation allows some light to pass. The condition usually remains stationary, but occasionally becomes complete. It causes interference with vision, the amount of which, according to the extent and density of the opacity, may be slight or great. If taken early, it is amenable to the usual surgical treatment.

TEMPERATURE.

I have seldom seen the temperature above the normal in rickety cases of uncomplicated course, though a it may be raised a degree or two at the invasion of the disease and in acute cases. I have often seen pyrexia in the case of pneumonic, gastrointestinal and other complications; but even when the patient is sweating very freely about the head and tossing off the bedclothes, the body-heat has not been appreciably raised. Indeed, I have often noticed that the temperature is actually subnormal, particularly when exhaustion or marasmus or wasting are present.

VARIETIES OF RICKETS

Various forms of rickets have been described, of which the following may here be considered - the foetal, the congenital, the acute and the late manifestations of the disease.

F o e t a l R i c k e t s.

This variety of rickets has been termed achondroplasia, chondrodystrophia foetalis and foetal cretinism. It results in defective growth of the bones and to dwarfing and deformity of the limbs, which may persist throughout the lifetime of the individual. The term has in the past been used to designate various conditions observed in the foetus or newborn infant resembling rickets; but many of these have been found to have nothing in common with that disease. The affection is of uncertain etiology; there is supposed to be some hereditary tendency, and it is observed in animals as well as mankind. It occurs during early intrauterine life and runs its course mainly between the third and sixth months of foetal existence. The consequent

deformities consist of the arms and legs being almost a half of their normal length, the bones thick and short, and the normal curves exaggerated. The fingers diverge, forming the so-called trident hand, and the child appears not unlike a basset hound. The head is large and, from shortening of the base of the skull, the nose is tilted up. The pelvis is deformed also. In later life the patient is generally from three to four feet in height. It is a rare condition, and it is not amenable to treatment.

C o n g e n i t a l R i c k e t s.

Children are sometimes born rachitic, though the frequency of this has been variously estimated. The signs are similar to those of the ordinary disease; but the main characteristic is the frequency of fractures, often complete, of the long bones. These fractures not uncommonly occur, according to Notta, in utero. Ashby has recorded a case in which deformity of the chest was present at the age of fourteen days, together with several fractures of the long bones. Curvatures of the bones are often seen. The cranium may be incompletely ossified. Though some cases recover and the fractures unite, the outlook for these infants is gloomy. The most that can be done is to feed them properly and treat the fratures by the usual surgical means.

A c u t e R i c k e t s.

This condition is sometimes described as multiple epiphysitis or multiple periostitis of the articular ends of the long bones; the changes, which in the ordinary form of rickets require months to develop, take place in a very short time. Not infrequently the patients give one the impression of having nothing the matter with them before the onset of this affection. Some have regarded it as an independent malady and the outcome of a constitutional predisposition; whereas others look upon it as a very acute form of rickets or an actual osseous inflammation. It seems probable, however, that the condition is not pure rickets, but the latter with concomitant infantile scurvy or Barlow's disease, which used to be termed haemorrhagic or scurvy rickets. Glisson (loc. cit.) spoke of the occurrence of scurvy in connection with rickets; but the disease, according to Hutchinson (Osler & McCrae's Syst. Med., i, 901) "seems to have been lost sight of until two centuries later when Müller (Königsb. med. Jahrbücher, 1859, i, p. 377) described some cases under the title of "acute rickets", a term which was adopted by other continental writers on the subject, such as Bohn and Hirschsprung. In 1873 Jalland (Med. Times & Gaz., 1873, i, p. 248) described a case in a child of ten months and considered it as identical with the scurvy of adults. Another case was published in 1876 by Thomas Smith (Trans. Path. Soc. London, xxvii, p. 219) who described it as one of 'haemorrhagic periostitis of several of the long bones with separation of the epiphyses', but failed to recognise its scorbutic nature. To Cheadle belongs the credit of first clearly emphasising the identity of such cases with the scurvy of adults, which he did in a paper (Lancet, 1878, ii, p. 685) on 'Three Cases of Scurvy supervening on Rickets in Young Children,' published in 1878. In 1881 Gee (St. Bart. Hosp. Reps., Vol. xvii, p. 9) published a series of cases under the name of osteal or periosteal cachexia, but in 1882 Cheadle (Lancet, 1882, ii, p. 48) again insisted on the

identity of such cases with scurvy.A year later Barlow (Trans.Royal Med.& Chir.Soc.,1883,lxvi,p.159)secured general recognition of Cheadle's views by a paper entitled 'On Cases described as 'Acute Rickets'which are Probably a Combination of Scurvy and Rickets,the Scurvy being an Essential and the Rickets a Variable Element'. This paper contained an exhaustive alinical and pathological account of the disease and has become a classical publication of the subject which on the continent has secured for infantile scurvy the title of Barlow's disease.The terms 'acute rickets' and 'scurvy rickets' are stil l sometimes used,but all later observations tend to show that the rickety element is a mere complication and not an essential part of the process.The latest and most exhaustive account of infantile scurvy was written by Cheadle(Syst.of Med.Allbutt),but almost every day adds to the literature of the disease.The condition may be produced by a diet consisting solely of preserved food,such as dried milk,sterilised so-called humanised milk,or peptonised milk.In older children the affection occasionally occurs when they are kept on a diet lacking vegetables.The principal lesions are to be found in the bones.The periosteum of an affected bone is thickened,vascular,and separated from the bone by blood clot.There are no inflammatory signs;the muscles of the affected region may be infiltrated with serum or blood. There is considerable rarefaction of the bones,the cancellous tissue being very porous and the normal marrow replaced by a highly vascular connective tissue.This rarefaction is due,it is affirmedmto delayed ossification.The serous cavities,joints,etc.,may show haemorrhages.The occurrence of periosteal haemorrhage and renderness,haemorrhagic stomatitis,and sometimes of purpura and haematuria characterises this disease.Infantile scurvy usually occurs between the ages of seven months and two years.The child cries whenever it is handled or disturbed.There is marked tenderness of one or more of the limbs,especially the lower ones;there is perhaps local swelling or oedema of the feet or thighs;and there not infrequently is also a conspicuous redness under the nails.The legs hang down as if paralysed,the infant not moving them on account of pain and tenderness.When a tooth is cut,the surrounding gum is seen to be purple and swollen.There is often more or less bright blood in the urine or stools,or contusion-like marks on the body-surface.Bleedings may take place into the orbital cavity or viscera;and the patients appear to be very bloodless at times.It is easy to recognise severe instances of the disease,but the mild or early ones may be overlooked.The nature of the diet and the therapeutic test are useful in its recognition.Infantile paralysis, rheumatism,epiphysitis and periostitis may be mistaken for the condition.In the first-mentioned there is no swelling of the affected extremity and other signs of scurvy are absent.Below the age of twelve months rheumatism is seldom seen.The swelling in infantile scurvy is not limited to the locality of the epiphyses,which fact distinguishes it from epiphysitis.In the case of periositis there may be some difficulty in diagnosis, if there are no haemorrhages in the gums and if other distinctive signs of scurvy are absent.A high temperature would probably indicate periositis,a normal body-heat being the usual thing in scurvy.The outlook for these patientsis favourable,as there is speedy recovery

under proper feeding.Sometimes such complications as bronchopneumonia carry off the subject of this ailment.

Late Rickets.

This is sometimes called rachitic tarda,and is an uncommon form of the affection in which there is a late appearance and a lengthy persistence of the characteristic anomalies observed.Deformities,such as knock-knee or flat-foot or bowleg,develop between the ages of nine and eighteen to twenty years.Some authorities hold that the malady is allied to osteomalacia;whereas others look upon it as relapsed rickets or an associate of masturbation and albuminuria.It is not of the nature of osteomalacia,as,according to Ashby and Wright(Dis.of Childr., p.216),the patients "never die of the disease,the process becomes arrested,and it does not occur under the conditions met with,nor attack the parts affected in osteomalacia".It is just as certain that masturbation and albuminuria are not invariable etiological conditions. The above authors affirm that it is due "simplyto weak health,bad air,long standing,poor food - in short,to bad hygienic conditions at the time when growth is active in the limbs - in fact,mainly to those causes which produce rickets in earlier life".Clutton holds that adolescent rickets is pathologically the same disease as infantile rickets,modified by the age of the patient.Observers are not agreed upon the point as to whether the adult form is a continuation of infantile rickets or a new development thereof.Against the view that it is a recrudescence of early rickets is the fact that the bones after recovery from this disease are usually eburnated and sclerosed,a condition in which it is not easy to suppose that a relapse would occur.If it be a continuation of infantile rickets,then the first attack must be very mild,unnoticed,and with no tendency to recovery;and if it is an entirely new development,then,the origin of rickets at any age from infancy to adolescence must be assumed.The invasion of the malady is not infrequently accompanied by pain in the limbs,which may be very severe,and weakness of the legs may be so pronounced that the patient cannot walk without assistance.There is enlargement of the epiphyses and beading of the ribs,and also sometimes a certain amount of deformity of the chest.Bending of the lower extremities is generally productive of a peculiar waddling,awkward gait.During the active stage of the affection an irregular rise of temperature may be observed.There may be an excess of lime salts in the urine.I have never heard of an uncomplicated case ending in death,though dangerous surgical operations may have to be performed for the relief of the osseous anomalies.The treatment is that of ordinary rickets.

COMPLICATIONS & SEQUELS

I have already shown that the normal evolution of rickets may be variously interrupted or changed by the development of such complications as bronchitis, gastric and intestinal troubles, which, in view of the general malnutrition of the patient, may prove dangerous.

During the convalescence of the disease one or other of the acute affections of childhood, such as scarlet fever or measles or pertussis, may occur; they may also invade the system during the course of rickets, and are always of gravity, particularly measles and whooping-cough. Rickety children seem predisposed to infectious diseases; and, according to Hansemann (Berl. klin. Woch., Feb. 26, March 5, 1906), there are seldom deaths from such affections as measles, scarlatina, and particularly whooping cough and diphtheria, unless the patient is or has been rachitic. He considers rickets not an osseous ailment but a perversion of metabolism, and adds that as kidney disease is associated with gout, in a similar way pulmonary and intestinal catarrh may be associated with rickets. Both Fagge and Jenner agree with him in regarding rickets as a diathetic condition akin to gout. It is a well-known fact that large numbers of rickety children die annually from various intercurrent affections such as the above. In measles there is a well-marked catarrh of the conjunctiva and nasal mucous membrane, and not infrequently also bronchitis or bronchopneumonia. In the case of a healthy child measles is comparatively seldom fatal in most instances; but should rickets be present, capillary bronchitis or other respiratory affection may carry off the patient. Other complications, e.g., convulsions, would be more likely to prove dangerous at such times. Whooping-cough is a very dangerous complication or sequel of rickets, largely on account of the softening of the ribs and enfeebled respiratory mechanism, the patient being unable to cope with the sudden spasmodic coughing fits or to ward off the threatening lung collapse. Not a few of these individuals meet with sudden death. The patient has little or no chance of recovery if phthisis be engrafted on the rachitic condition. Still, it is fortunately rare to find tuberculosis occur at the same time as this disease, it being alleged that the circulating toxin has some germicidal effect on the bacillus tuberculosis. But should this complication or sequel occur, the badly nourished infant obviously would have little chance of surviving the conjoint effects of the two ailments. It may happen that in the case of the rachitic infant the tonsils act like a trap to the diphtheria bacillus; and the action of the diphtheria toxin on the vagus and intercostal nerves renders the affection, in the presence of rachitic circulatory and respiratory debilitations, particularly dangerous. Scarlatina is apt to be of severe evolution in the case of a child already rachitic. Convulsions, early or late in the disease, would be very likely to ensue, and the catarrhal condition of the gastrointestinal tract would favour a lethal issue. Great care should be taken to prevent the rachitic patient taking epidemic summer diarrhoea,

which is particularly weakening and very frequently fatal in these cases. Experience has convinced me that epidemics of influenza have the severest forms of the disease and the most complications amongst rachitic children.

Conclusions.- The tissues of the rachitic child are particularly vulnerable and constitute a favourable nidus for the development of infectious and other intercurrent ailments; when such occur, they are very apt to prove fatal.

DIAGNOSIS

GENERAL DIAGNOSIS.

Bearing in mind the symptomatology of rickets as already outlined(particularly the deformities of the osseous system,the backward development,the tardy dentition,the late acquirement of the art of walking,the head-sweating,nocturnal restlessness,etc.)there should be little diagnostic difficulty as a rule.The enlarged abdomen and osseous anomalies,in fact,usually suggest the disease at first sight.But it is sometimes by no means easy to recognise some of the early cases of irregular evolution,in which perhaps one system or part of the body alone may be affected.Yet these cases must not be overlooked,as the well-established or complicated disease may ultimately kill the child,whereas at first a cure might be very easy.It is particularly important that too great importance should not be attached to the fatness of the infant,the sign not being indicative of the absence of the disease as the mothers and patent food mongers would insist.Yet emaciation is no proof of its presence,as the child may be reduced almost to a skeleton by marasmus and be quite free from rachitic taint.According to Eustace Smith(loc.cit.),the "head elongated from before backwards;the square,straight, prominent forehead;the smallface;the beaded ribs;the deformed chest;the twisted,distorted limbs;the immobility and quiet of the little creature as he sits - if he can sit - with bowed spine and head thrown back,gazing around him with vacant eyes;all these characteristic symptoms leave no room for doubt as to the nature of the disease".It is the attenuated forms,the partial varieties,and the initial stage of the affection which call for close study ere rickets can be diagnosed with approach to certainty.The parents themselves may not suspect the presence of the malady;for,as the above author remarks,the "plumpness of the child,indeed,is the subject of much admiration.The absence of teeth(often at a late age)is looked upon as an innocent peculiarity,and cases are quoted of relations,male and female,in whom the same tardy dentition was observed.It is not until some complication arises,or the disease enters a new phase, that anything is noticed to excite alarm.There can be no doubt that late teething is never a normal phenomenon. As Jenner(loc.cit.)would have it,if the ninth month passes without the eruption of a tooth,the cause should be carefully investigated,and will usually be found to be the disease under consideration.It is usually the disinclination or inability to walk that first draws the attention of the parents,and advice is not infrequently sought for this condition first of all,as paralysis is sometimes feared.But examination very soon demonstrates that the extremities are not paralysed.Though the child may not be able to stand,nevertheless the power of movement is not abolished,showing that the muscles,though weak and flabby,are capable of action;and the real nature of the disease will be indicated by the gradual onset,the retention of the reflexes and osseous anomalies.Beading of the ribs,though very common in rickets,is not absolute proof of its existence;for it

may be seen in quite healthy infants soon after birth, these beadings not having the same histological characteristics as rickety rosaries. Further, the softening of the cranial bones, with thinning of their edges and some separation of the sutures are pathognomonic of this disease, though Fede and Finizzio would have it that it would be indicated by the softened osseous tissue yielding to pressure. In very early cases constipation and naemia may be the only signs of rickets present and persistent; in the absence of discoverable cause rickets may be strongly suspected and the proper treatment instituted. The same remark holds good if there are unaccountable catarrhs of the respiratory and gastrointestinal mucous membranes. The nervous symptoms may also be very suggestive, particularly nocturnal perspirations and restlessness, as well as convulsions after the age of six months in the absence of obvious provocative disease. "The most important symptoms for diagnosis," remarks Holt (Dis. of Childr., p.267) "are sweating of the head, craniotabes, great restlessness at night, delayed dentition, and enlarged fontanelle. All of these separately may mean something else, but collectively they can mean nothing but rickets." In short, in early stages of the disease the constitutional changes are more likely to reveal the malady than the characteristic osseous troubles.

DIFFERENTIAL DIAGNOSIS.

There are very many affections for which rickets, at some period or other during its evolution, may be mistaken, the following being the principal of these:

SYPHILIS.

We have already seen that the connection of rickets with syphilis has been much mooted, some affirming that it is closely related to the specific disease and other that there is no relation whatever, except that it undergoes aggravation with a syphilitic attack. The presence or absence of rachitic phenonena or of congenital syphilitic manifestations may call for a very close study of the case. In favour of syphilis we have the history of the parents, and perhaps a history also of miscarriages or abortions or premature children in the case of the mother. Syphilis occurs not later than the third month and teething is usually early; there are various skin eruptions, fissures of the angles of the mouth, coryza, snuffles, cachexia, mucous patches about the anus, etc. Syphilis is a bone producer; rickets is a cartilage former. Syphilis produces more extensive and diffuse thickening of the lower end of the diaphyses, also nodes and gummata. The osseous lesions of syphilis are destructive and lead to separation of the epiphyses and shaft and to the formation of abscesses. The early form of osseous lesion is an acute epiphysitis, with inflammation of the shaft and soft parts secondarily. The epiphyseal enlargement of the wrist in syphilis attacks usually only one bone, thus strikingly differing from rickets. Chronic osteoperiostitis is found in late hereditary syphilis, not infrequently attacking the tibia and producing the symptom of Lannelongue; in this so-called syphilitic tibia there is a forward curve of the anterior border of the bone like a sabre blade, and sometimes the bone is bent inwards at its lower third. The entire shaft of the bone may be affected and enlarged to perhaps twice its natural size. In other cases

the swelling may be near the epiphyses and give rise to interference with the function of the joint.There may also be ulcers and scars of the latter along the bone. Nodes may likewise be present here and there,and these may break down and end in necrosis.To distinguish the rachitic curve from the syphilitic one it is necessary to bear in mind that rickets occurs usually under three years,whereas the syphilitic anomaly may be seen up to about nine years.The history of the two differs;in the one we have signs of rickets,in the other a history of syphilis and its usual manifestations.In rickets the direction of the curve is antero-external or antero-internal,whereas in syphilis it is purely anterior.In rickets the curve is generally located in the upper or lower third;in syphilis it is in the middle third of the shaft.The crest of the tibia is sharp;in syphilis it is smooth and rounded.The surfaces of the tibia in the case of rickets are flat or concave;in syphilis a convex-ity is observed.The syphilitic head is sometimes of irregular shape;that is,the rachitic is as already described.Osteophytic growth is seen around the anterior fontanelle,which may appear to be in a hollow;the natiform skull is present and there may also be craniotabes. The lesions in the other bones are similar or nearly always symmetrical and multiple;some of the cranial nodes may break down and culminate in a necrotic condition.

TUBERCULOSIS.

Infants are sometimes tuberculous and present signs not unlike those of rachitic chest complaints;Emmett found fourteen per cent.of the children in the infant hospitals of New York under the influence of the bacillus tuberculosis;and Holt,out of one hundred and forty-three cases,found fifty-seven in the first year and thirty-nine in the second.It is sometimes not easy to make a definite diagnosis in these cases;but it may be suspected when the teeth appear irregularly and when their eruption is unusually delayed;excessive perspiration upon the scalp and obstinate diarrhoea or constipation afford valuable indication of the malady.The bacteriological findings and the general course of the disease are of prime importance.

INTESTINAL PARASITES.

The peculiar condition of the tongue may raise a suspicion of worms;but a close study of the case and the effect of anthelmintics will usually eliminate all error.

SCURVY.

The development of infantile scurvy at the rachitic age may lead to diagnostic confusion,but not usually in view of the circumstances that surround its development and prevalence.These circumstances are altogether peculiar and characteristic,and involve the absence of vegetable food as a rpime factor and exposure to cold,fatigue, mental despondency,or other predisposing influences as accessory in its production.The scorbutic cachexia is indicated by the sallow or earthy hue of the skin;the spongy gums;the discoloration of the surface;the pains in the limbs and joints;the sense of weariness;and later the exhaustion,dyspnoea on the slightest exertion; the bloody and fibrinous effusions into the connective tissues and muscles about the joints and into the pleurae,pericardium and peritoneum;the stiffness and contraction of the legs,- furnish a complexus of symptoms not met with in any other affection than scurvy.The

rapid improvement of scorbutic cases under antiscorbutic diet is also a noticeable feature not observed in the case of rickets.

CHRONIC HYDROCEPHALUS.

This is sometimes suggested by the large size of the rachitic head.But the true hydrocephalic head is rounded rather than square or quadrate,and there is greater disproportion between the head and the face. There is no sensation of thickening of the bones of the vault of the skull on palapation;the fontanelles are more patent and,if there be a large accumulation of liquid,the sutures are not infrequently very wide apart. The anterior fontanelle in hydrocephalus is bulging;in rickets it is depressed.When the two conditions co-exist the diagnosis is rendered more difficult;but as long as there is depression of the anterior fontanelle,hydrocephalus may be considered absent.In those cases in which the disease arises after closure of the fontanelle and sutures it may be impossible to distinguish the two conditions,and it is only when symptoms arise from increased tension in the cerebral ventricles that the diagnosis may be determined with approach to certainty.

SYPHILITIC CRANIOTABES.

Craniotabes is said to be one of the earliest signs of rickets,it being seldom seen before the third month and rarely after the second year.Carpenter thought it closely connected with syphilis;Still thinks that it occurs in rickets apart from syphilis,but that the condition is aggravated when the latter affection is present. Not infrequently it is only by a careful examination that the presence or absence of other rachitic manifestations may be determined and syphilitic general phenomena discovered or eliminated.The family and personal history is of great importance.The presence of the spironema pallida might also be sought for.

SPINAL CARIES.

The humpback of rickets is sometimes mistaken for that produced by spinal caries or Pott's disease arising from tuberculosis of the vertebral column.But in rickets there is not the angular gibbosity of the tubercular disease,it being rather a general curving of the whole of the dorsal spine,with perhaps some lateral curvature.In mild or moderately severe cases of rickets this kyphosis disappears when the child is made to lie face downwards and gentle traction is made on the legs,which same also occurs when the child is lifted up and supported under the arms.But in severe chronic cases there may be no such disappearance of the curve.The tubercular condition is seldomseen under the age of eighteen months, a time when rickets is common.There is great local pain, and rigidity which is at first voluntary,but aftewards due to ankylosis;there may also be paraplegia from lesion of the spinal cord.The ribs of the diseased vertebrae are carried backwards;they lose their ordinary curve and pigeon-breast results.The history of the case and the absence of rachitic indications are very important diagnostic factors;and the same points would differentiate its cervical and lumbar locations,and the occurrence of abscesses in the different regions must not be overlooked.A lateral curvature of the spine,or scoliosis, is,according to my experience,nearly always rachitic. But it may arise from such other causes as the following: First,congenital malformation of the vertebrae.Second, static scoliosis,that is,short-leg congenital or path-

ological conditions,e.g.,dislocation of the hip,contractures of the knee or hip,knock-knee,or various paralyses giving rise to unequal muscular action.Third,hysterical scoliosis;this may suddenly disappear spontaneously or under anaesthesia.Fourth,pleurisy and empyema;the history here is usually diagnostic.Fifth,the scoliosis of females about puberty;it is usually associated with laborious occupations involving muscular fatigue,with resulting relaxation of the muscles and ligaments.Sixth, Sprengel's shoulder or congenital elevation of the scapula,with attenuation of the overlying muscles.Seventh, early Pott's disease as already described.Eighth,unequal focal length of the two eyes causing a twisting of the body to the weaker side.Ninth,nasal obstruction and adenoids.Tenth,torticollis.

OSTEOMALACIA.

It is seldom that this affection is mistaken for rickets,as it usually occurs in grown-up persons,is progressive,and has a special etiology.Sometimes, however,cases are observed in children,characterised by great softening and beding of the bones,but without the enlarged epiphyses and big quadrate head and other signs of rickets."Some of these cases",says Still(loc.cit.)"are probably much nearer related to the so-called osteomalacia of adults.It may be that in some cases a condition like the osteoporosis produced experimentally in puppies occurs in children also.Rickets is almost invariably the cause of such things as relaxation of the ligaments with resulting abnormal mobility of the joints.This relaxation is best seen when the affection has its onset after the second year,when the child has begun to walk, and is most marked,perhaps,in the knees and ankles,where the weight of the body is most operative for deformity.

CONGENITAL DISLOCATION OF THE HIP.

Rickets may be simulated by this affection,as there is usually knock-knee.But here it is usually easy to drag the trochanter upwards and downwards without causing the child any considerable pain or inconvenience, which,of course,in rickets would not be the case.Further,the position of the head of the femur and the various measurements are sufficiently suggestive.

CRETINISM.

Here we have such characteristic symptoms as mental weakness,vacant physiognomy,depression of the head on the chest,perhaps absence of the thyroid gland,coarseness of the skin and hair,and fatty deposition in the supraclavicular fossae and elsewhere.The history of the case is also important,as is also the future course of the disease and result of treatment(thyroid medication, etc.).

PLEURISY.

The history of the case and the absence of the characteristic rachitic deformities will suffice for the elimination of this affection.

TABES MESENTERICA.

This common affection of childhood may be suggested in rickety cases by the enlarged abdomen and other local symptoms;but the osseous and other anomalies of rickets would be absent and the subsequent course of the case would clear up all doubt.

EPILEPSY.

It is possible that the convulsions seen in rickety children might erroneously be assigned to this disease;

but the hostory of the case and the character of the spasms will dufferentiate the two diseases.

INFANTILE PARALYSIS.

In this affection,which is commonly called acute poliomyelitic anterior,there is an absence of both the superficial and depp reflexes,and the reaction of degeneration is soon established in the atrophied muscles. Particular groups of muscles are apt to be affected,and ultimately contractures are observed;in rickets all these phenomena are absent and the limbs have the power of movement under stimulation.

PSEUDOHYPERTROPHIC PARALYSIS.

Marked lordosis in rickets may suggest this disease, which is characterised by such phenomena as enormous development of the calf and other muscles,the gait,and a peculiar manner of rising from the ground.Special rachitic signs are absent.

DIPHTHERITIC PARALYSIS.

This is sometimes seen to occur after a mild pharyngeal expression which has perhaps been overlooked.But there is usually some alteration of the voice and perhaps regurgitation of the food through the nose.The patients commonly squint,and the patellar reflex is usually in abeyance.In rickets,however,there is no true paralysis,the muscles being merely weak from existing nutritional defects.

PARAPLEGIA.

In this there is a paralytic condition;but in rickets the power of movement of the leg is present,there are no girdle pains and there are no muscular spasms from descending degeneration.

PROGNOSIS

Rickets is seldom in itself a fatal disease, the danger to life existing in complicated cases only, as a rule; infancy is always a more or less critical period, and the occurrence of this disease makes it more so. But in ordinary cases early improvement is observed under proper dieting and management; the enlarged epiphyses undergo diminution, the thoracic deformities abate, and the other osseous troubles tend to disappear, though not infrequently some slight deformity, such as bowlegs, remai-ns and the patient is stunted in growth. Rickets, as we have seen, is responsible for convulsions, which frequently are productive of a vast infantile mortality. The course and severity of the disease will have an important bearing on the prognosis, the affection lasting, except in those rare instances of acute rickets which run their course in a few weeks, for months or even years. The disease may, however, occasion so severe a cachexia that the patient dies in a state of exhaustion and collapse. The earlier the age at which rickets commences the more rapid and severe are the changes occasioned in the bones and the associated anomalies, especially those of the respiratory organs. The interference with the child's health and nutrition will thereby be aggravated. The prognosis depending on the nutritive disturbance and the complications, it is more favourable the older the patient - it being more favourable in the second year than earlier. The time of the year affects the prognosis somewhat, the disease being worse in the winter than the summer when children can lead the outdoor life. The vigour of the patient affects the outlook, obviously, as does the social status, a poor child being less likely to receive proper care and treatment than a wealthy one. The employment of antirachitic measures at an early date may result in the disease being checked or averted without the severe osseous lesions having time to occur. But if the affection secures a firm hold and has bone and visceral lesions, the cure will be slowly effected and the child not be out of danger for many months. The degree of osseous affection has an important bearing on the prognosis and in direct proportion thereto; the same remark applies to the general perversion of nutrition obtaining. A slight amount of deformity, as of one limb, is not likely to cause much trouble; but if the entire osseous system is involved, the danger is great; the cure must be slow and there is the additional risk of the necessary surgical operations in severe cases of deformity. If there is much deformity of the thorax and pronounced softening of the ribs, there is always cause for anxiety. Owing to the interference with respiration in these cases, there is deficient aeration of the blood, with resulting deficiency of oxidation and removal of the waste products of metabolism. These cases commonly suffer from catarrhal troubles; no matter how carefully the patient be protected against chills, catarrh of the mucous membranes will arise, owing to the excessive sensitiveness of the rachitic individual to changes of temperature. Such catarrhs would perhaps have very little

effect upon healthy children;but they are very dangerous in the case of the rachitic subject and not infrequently culminate in bronchitis or bronchopneumonia,which are obviously serious affections in the weakened child.It is this tendency to catarrh which makes measles and whooping-cough more to be feared perhaps than any other malady.Catarrh of the stomach and intestines is also of unfavourable prognosis,as some intercurrent disease may end the patient's life.Diarrhoea is always a serious accident,and the tendnecy to it in rickets is well known.Laryngismus is sometimes a grave condition,but,as a rule,it is not directly responsible for a fatal issue. Tetany may also prove fatal.The nervous system in these cases may be permanently weakened;according to Gowers, ten per cent.of all cases of epilepsy present a rachitic history,whilst Coutts says that this is too low an estimate,seventeen per cent.being about correct.The occurrence of hydrocephalus is of grave import,especially when of severe degree.Even in mild cases the patient is apt to develop into a neurotic individual and to be mentally more or less unbalanced or weak.Some of the rachitic cases carry the effects of their former malady throughout life and are handicapped thereby in the securement of suitable employment;they may be dwarfed and be a source of aversion to their fellows.I have already shown the danger to women during parturition from one or other of the rachitic pelves.The possibility of the so-called late rickets must be borne in mind and all possible done to prevent its occurrence at the usual age.

TREATMENT

GENERAL CONSIDERATIONS

Rickets is one the affections thatshould not exist, and its present enormous prevalence is obviously a blot on our high-grade civilisation.Far-reaching questions are concerned in its management,and have largely to do with the provision of clean and hygienic dwellings,sufficient clothing,and the all-important subject of breast-feeding,which is a natural and honourable function too often neglected by nothers even in homes where wealth and intelligence are by no means lacking.Its enormous prevalence is a matter for public concern,and its mortality,- direct or indirect,- seems almost as great as ever,despite the advances made in general and special science.Not only do young children die of the disease, but large numbers of them grow up unhealthy in various respects and deformed,being subject,too,to incapacitation from intercurrent affections and experiencing predispositions to a number of deadly or debilitating ailments.Male rachitic may have their wage-earning powers hampered,and the women have much to fear from childbirth when deformity of the pelvis exists.The rachitic question is perhaps just as important as the alcohol question;the latter receives close attention everywhere,the former does not:yet the one is just as dangerous or inconvenient to the nation,and the days of special legislation bearing upon infant-rearing must surely be at hand.Undoubtedly insanitary conditions in the home are not nearly so prevalent as formerly,thanks to public health enactments;but infant poisoning by artificial and other so-called foods appears to be going on unchecked.The parents require much information regarding the management and protection of their children;and,if they are unable or unwilling to properly undertake the responsibility on up-to-date lines,the State must interfere.In this way it may confidently be expected that ere long a healthier race will be created,and the administration of drugs little demanded,general management, hygiene and dietetics being probably quite capable of rendering the disease extinct.

PROPHYLAXIS AND GENERAL MANAGEMENT OF THE DISEASE

This subject must necessarily include factors concerning the parents and the child both before and after birth.

The Parents.

THE FATHER.

It is obviously difficult to so arrange matters in the case of the father that rickets will not appear in the child,though it is probable that much might be done by efforts directed to that end.Should the father have had rickets or come of a rachitic stock or has sired rickety children,then it is necessary to explain the whole question to him and endeavour to make him carry out prophylactic measures of the most rigorous kind,his responsibility in this respect being great.Especially must he take care that his wife brings up the child on the breast and that she is not allowed to work in the

mill or factory.He should be cautioned against the evil effects of alcohol,and be persuaded to lead a virtuous and correct life.He should see that his wife performs her maternal and domestic duties,but nothing more;the man who loafs his time away on the earnings of his wife is indeed a curse to the race.He should be taught to take a real practical pride in his home and be the one and only contributor to its support.The banishment of the two bottles- the alcohol and the feeding - is a commendable object to be achieved.

THE MOTHER.

In view of the fact that a healthy and robust child will scarcely be produced by a mother who is overworked, underfed,or existing in the polluted atmosphere of an unhealthy home,the necessity for care as regards her general health is obvious.From her own early days attention to hygienic and saltuary rules should be instilled.Even in ancient times,physicians advised that the girls should harden their bodies with the exercise of running,wrestling,throwing the bar,and casting the dart, to the end that "the fruit wherewith they might afterwards be conceived,taking nourishment of a strong and lusty body,should shoot out and spread the better!"Though it would be incorrect to affirm that healthy women invariably bring forth healthy children,yet is no exaggeration to insist that the prospective mother,who obeys the laws of health and hygiene,will most likely bear better children than the woman who is a mere drudge and neglects these rules.The employment of pregnant and puerperal women in factories,mills or workshops is at all times to be condemned.To say nothing of the so-called dangerous trades,where the risk of lead-poisoning,amongst other evils,is a fertile source of abortion and other sequels,it is lamentable that the State should tolerate female hands in these places almost to the very day of their confinement,and allow them to return to work after a fortnight or so of the puerperium,leaving the child to be taken care of by someone else.These women,it may be,resent the monotony of the home,as shopgirls and actresses,etc.,are said to do;they love the excitement and gossip and scandals of the factory;and their weekly wage is keenly appreciated and craved.But in any case,for the sake of the children,who are the creators of a future generation,female labour should not be allowed during at least the last three months of pregnancy,and never for six months after the birth of the infant.She should be taught that rickets is largely due to dietetic errors,that the affection may be obviated or relieved by the correction of these errors,and that it is by breast-feeding up to eight or nine months she becomes possessed of a great bulwark against the development of the malady.It is true that rickets does sometimes occur in breast-fed infants;but it will generally be found that they have either been suckled for too long a period or that some other food,such as bread, biscuit,or farinaceous material,has been added to the diet at this age.She should be made to understand that milk of sterling quality should be the entire nourishment for the greater part of the first year,and that it should dominate the dietetic scene for another twelve months.If she has to bring up her child by artificial means,she should take care that the proportion

of fats does not fall below the normal amount,and that the presence of starch does not interfere with their due assimilation.The importance of frsh air and sunlight must be carefully pointed out.She should take her infant out into the open air for at least three or four hours daily - warmly clad in cold weather,but clothed so that the limbs are in no way confined.She should take care to have plenty of ventilation in the nursery,or,if she be very poor,in the general living-room,with due avoidance of draughts and as much sunlight as she can secure. In order to ward off bony deformities,she should not allow her child to stand or walk during the active stage of the disease;and if the case is a very severe one, even sitting up in bed should not be allowed.She should be made aware of the danger of such complications as bronchitic,bronchopneumonia and gastrointestinal disease. She should be encouraged to keep her house clean and attractive;and during her own childhood general points covering infant rearing might be demonstrated on the doll,later a live infant being employed.Courses of lectures should be attendd on the subject whenever possible.An hour or so occasionally at a public crêche would do her no harm.Something in the nature of prizes or rewards(in money or in kind)might well be devised for women who take a practical and intelligent interest in the subject.Lectures or classes might advantageously be attended by the pregnant woman;the so-called "health talks"also do good.At this time her food should be carefully attended to;it should be of the most nutritious kind and be devoid of spices,condiments,alcohol, excessive teas or coffee,and sugar which is apt to overburden the renal organs.This is important in view also of the possible effects on the child of maternal autointoxication.She should take plenty of walking exercise and avoid excitement of every sort.The foreign method of taking pregnant women into special hospitals has not yet been adopted in this country,as the element of charity contingent thereto seems repugnant as yet.Under no circumstances should she be allowed work in the factory at this time."The nation",observes Money(Riches and Poverty,p.169),"must set its face against the employment of married women in factories,for the proper sphere of her work is in her own home.In the case of factory workers the employer must be made to furnish a maternity fund,and probably if he is thus penalised,he will prefer not to employ married women to the very great advantage of the labour market and the nation".

The general conduct of the mother during the period of lactation is one of cardinal importance.She should be made to realise the honourable and responsible character of the dietetic act and be made to take a pride in it;there is usually no need for her to leave to the patent-food mongers what she can easily do herself. Maternal milk is the ideal infant food,and she must be made thoroughly aware of this;nothing can perfectly replace it without a certain amount of risk to the child during the first year of its life when the mortality is so great.Even depots for the supply of sterilised milk have the great and special disadvantage that they tend to discourage,unintentionally it is true,breast feeding;were these places made free to the necessitous, as has been done abroad,the drawback would still exist.

Having duly impressed the mother with the urgent necessity for breast-feeding, she should be made aware of the undesirability of practising the method beyond the normal time, i.e., the first twelve months of the infant's life. In order to preserve the proper standard of her milk, she must avoid all excitements and worries and be made to engage in a quiet and regular existence. Her breasts should be supervised and kept as aseptic and healthy as possible in the usual way. She should not feed her infant promiscuously, but at certain hours only, and with unfailing regularity, lest gastrointestinal and other disturbances result. If the child be troublesome in this respect, it should be made to sleep by itself in some other part of the house; continual draining of the mother is sure to do more harm than good. At the age of about five months the infant should be made to fast all night so far as breast-milk is concerned. About three months later, when the proteids of the maternal milk tend to run short, she should have a supporting diet in which there is a considerable proprtion of meat. Goldmann (Therap. Monat., July, 1904) speaks highly of four-hourly drachm doses of lactagol, made from cotton seeds, for stimulating the supply of milk; and Burzagli (Pediatr., April, 1906) is a believer in the administration of infusion of aniseed and the application of cold compresses to the breasts. No good can be done by the administration of stout, porter or other alcoholic drinks. If the milk be too rich for the infant and occasion gastrointestinal troubles, the mother is probably not taking sufficient exercise and feeding improperly; the percentage of fat can, however, be easily reduced in this way. Anaemia must be corrected; it is true that such women give plenty of milk, but it is very short in fat and other solids. The child has usually to be weaned in these cases. Should she become pregnant whilst nursing, the child must be taken off the breast; for then the milk deteriorates quickly and is apt to seriously interfere with the infant's health. It is also harmful to the mother, as the child has to feed to excess, and therefore undermines her health; besides, abortion is apt to occur in these cases, and then we have special risks. For the first month or so the child should be fed every two hours, then every two and a half hours until it is three months of age, when it should have no nourishment until the lapse of three hours. Should the child cry between meals, there is probably thirst - it is strange how thirsty some children by nature are - which a drink of plain water will relieve. The progress of the child should be estimated by weekly weighings and recording on a card. For this purpose machines and stationery are supplied by certain firms at a very small cost; every medical man at least should possess one. The child of a mother with a poor supply of breast milk should have its natural diet supplemented with cow's milk in alternate doses, or one just before it is put to the breast. The natural supply should not be discarded in these cases, as the natural ferments of maternal milk are of great importance, according to recognised authorities, in the prevention of rickets. In cases of twins this mixed-feeding method is of great service. It is both undesirable and unsafe to keep an infant on the breast too long; it should be weaned after

the ninth month;but the weaning should not be suddenly performed,it being better to gradually accustom the infant to occasional bottle-feeds and so familiarise it with the change of food.Sometimes the weight of the child falls off before the time of weaning,and then it may be necessary to wean or supplement at once.It is strange what a firm hold the conception-prevention idea has upon mothers,even those of good social position and intelligence;they think that by prolonging the act of lactation conception will not occur;they gloat over the successes,but utterly disregard the failures.Something really should be done by way of widespread instruction on this important point,as prolongation of the act beyond the time named impoverishes the milk,especially as regards the proteid constituent,and the child may actually be starved into rickets or other ailments;besides,it is a very debilitating drain upon the mother.These persons therefore stand in need of much enlightenment not only on the point referred to,but on a number of things concerning the welfare of the child as well.To hold the attention of an ordinary woman,especially a nursing female,is,most people will allow,for the duration of a speech is more or less of a gargantuan task.The medical attendant is accordingly handicapped in his work;but he can do much by way of recommending suitable books for home study;some of the best I know are Ashby's"Health in the Nursery", Holt's "The Care and Feeding of Children", Curgenven's "The Child's Diet",and Pritchard's "Infant Education"Thus the mother will come to take a really practical interest in the child;she may even keep a sort of diary of its progression,weight it regularly or perhaps cause her husband to photograph it now and then for comparison with the standard.So the very earliest indications of rickets will be detected and the suitable remedies employed.The midwife can do much to help her in this and other meritorious work.And in some places there are female inspectors who can exert their official and trained influence for the benefit of all concerned.The instruction of the relatives must not be neglected;and the family"wise old bird",the grandmother(maternal or paternal)requires handling on the most careful and diplomatic lines.Make an enemy of this influential persons,and the work of months may be forthwith undone;cultivate her esteem,and excellent results may accrue.Amongst the poorer classes there is much to be said also for the bonus system.

INFANT FEEDING:WITH SPECIAL REFERENCE TO RACHITIC INDICATIONS.

General Considerations.

The whole subject of dietetic is one of inimical importance to the present and future of the child,the exercise of care and intelligence in this respect usually meaning freedom from the disease under consideration.As is well-known,the natural food of the infant is the milk from its mother's breast.The desirability of this should require no insistence;but artificial feeding is nowadays far too common,according to my experience,amongst both the poor and the rich,the former being anxious to return to work or indolence,the latter to shirk their obvious responsibilities,as soon after confinement as possible.The milk of the mother is specially adapted to the rearing of the child,it containing all the necessary nourishing materials in perfect proportion as a rule,as well as special and

essential ferments, and various antibodies or antitoxins of prime importance in the disease-resistance of the child. The child's stomach at birth is weak; but nature supplies for eight or ten days a weak milk, of colostrum, which is adapted to place no undue strain on the organ. Gradually the stomach becomes stronger, and in view of this progressive tonicity, as it were, the organ should be slowly and surely trained to make the most of its oportunities without the indication of dilatation or other troubles; in rickets it is particularly important that there should be no overtaxation of the gastric powers. Weighing of the infant, as stated, is an important aid to infant feeding. "In your practice, therefore," advises Budin (The Nursling, p.84) "always have recourse to the balance. Recommend its usage at all times, knowing that nothing can replace it as a means by which to estimate the development of the nurslings." The whole subject is a vast one and somewhat inclined to be complicated and confused; for convenience, therefore, I purpose dealing with it under the following headings:

BREAST FEEDING.

Mother's milk is a natural food upon which the infant will thrive, if her health be good, in the vast majority of instances; and the growing tendency for mothers to abandon this natural duty is largely responsible for the increase of rickets and infantile mortality generally. Breast milk is the standard to be adopted for all schemes of infant feeding; the milk of various animals, such as the cow and the goat and the ass, are suitable and necessary in certain cases, but the so-called infants' foods are many of them worthless as compared with certain simple preparations shortly to be described, and they are by no means uniform in composition. Human milk varies somewhat as regards its constituents, according to authorities. Hutchinson (Food and Dietetics) finds its average analysis as follows:

Proteids	1.5 per cent.
Fat	3.5 "
Lactine	6.5 "
Mineral Salts	0.2 "
Other Constituents	0.6 "
Water	87.7 "

Johanessan analysed the milk of twenty-five primiparae and multiparae, varying in age from twenty to forty-six years, during the first three months of infancy and found

Proteids	0.06 - 2 per cent.
Fat	0.63 - 6.65 "
Milk Sugar	2.55 - 9.77 "

Another estimation is to the following effect:

Fats	3.2 per cent.
Proteids (Casein)	2.1 "
Milk Sugar	6.0 "
Salts	0.2 "

Rotch's tabulation (Pediatrics), according to quality, is as follows:

	Normal	Poor	Over Rich	Bad
Fats	4	1.50	5.10	0.80
Proteids	1-2	2.40	3.50	4.50
Lactose	7	4.00	7.50	5.00
Ash	0.2	0:09	0.25	0.09
Total Solids	12-13	7.99	16.35	10.39
Water	88-87	92.01	83.65	89.61
	100-100	100.00	100.00	100.00

The difference of opinion of analysts of human milk may further be instanced by the following table by Ashby and Wright:

	Solids	Proteids	Fats	Lactose	Salts
Pfeiffer	11.778	1.994	3.107	6.303	.192
Hoffmann	13.340	1.030	4.070	7.030	.210
Leeds	13.268	1.995	4.131	6.936	.201
Luff	11.490	2.350	2.410	6.390	.340
Adriance	12	1-2	3-4	6-7	.20
		Colostrum			
Pfeiffer	15.7	9.756	2.954	2.942	.408

The composition of the milk varies according to the conditions of the mother. Thus there is poorness in proteids in the case of blondes and those who, for some reason or other, are badly nourished; whereas the proteids are rich in primiparae, in whom also the sugar and fat are abundant. Extensive analyses have shown that the milk is richer in fat from twenty ro twenty-five; richer in proteids from the latter age to thirty; and richer in sugar beyond the latter time of life. From various parts of the world we have information to the effect that, in localities where breast feeding is universal, rickets is next thing to unknown. This point is well instances in the case of Japan, India and Burma, where there are the additional advantages of open-air life and comparative freedom from overcrowding. I have, however seen rickets sometimes in breast-fed children, but mostly from prolonged lactation or ill-health of the mother. Adriance (Arch. Ped., 1903) has given attention to this question and finds it by no means uncommon to encounter rickets in these children, particularly of the cranial type and from lack of bone-forming material in the maternal supply; he does not consider the fats, quite so operative in the production of rickets as the fats. We may take it, then, that breast feeding should be attempted in all cases, except when the mother is in ill-health from any cause, such as tuberculosis or syphilis, or has had the puerperium complicated with haemorrhage, septicaemia or other accidents of a very debilitating kind. Breast feeding may be impossible owing to the fact that no milk is secreted or that the milk disappears, as it sometimes does, when the mother gets up; but, in the absence of contraindications, it should be continued up to the ninth month of her infant's age. Holt has formulated certain rules for the determination of breast feeding or its avoidance. First, latent or active tuberculosis in the mother prohibits the child being put to her breast; for the infant may become infected thereby, her disease will be accelerated, and her cure will probably become impossible. Second, no infant should be nursed by a mother who suffers from some serious complication, such as Bright's disease, convulsions, severe haemorrhage, or septic infection, during pregnancy, parturition or thereafter. Third, breast feeding is contraindicated if the mother has chorea or epilepsy. Fourth, if the mother is very weak or has any serious chronic disease, the child will derive little, if any, benefit from being reared on the breast. Fifth, breast feeding should not be attempted where experience has shown on two previous occasions, under favourable conditions, that the mother is unable to nourish her infant. Sixth, it is obviously impossible for her to feed her child on the breast when there is

an entire absence of milk.The mother had better bring up the child by hand if she is unable to give it a proper supply of breast milk;she should begin this early,so that the infant's stomach may be brought into action when in a comparatively good condition.Thetraining of the mother should be commenced even during pregnancy;the breasts should be regularly inspected,and if the nipples are short or retracted,this should be corrected by gentle pulling on the nipple several times a day.Should the retraction be great,the use of the breast pump is called for.The hygiene of the mammary glands should be carefully supervised during the whole period of lactation; asepticity is absolutely necessary,and after each feed the gland should be well washed with some such weak antseptic solution as boracic acid.For about two days after its birth the infant receives only colostrum,which has the effect of promoting the action of the bowels to the elimination of the brownish material,called meconium, accumulated during intrauterine life.Though there are practically no nourishing constituents in this secretion,the infant should be regularly applied to the breasts, so that the speedy establishment of the milk may be promoted;the third day usually sees this,but it may be a day or two later in certain instances.During the first twenty-four hours of life the child usually drains the breasts of about six ounces of colostrum;but it is sometimes useful to supplement this with a teaspoonful or two of five per cent.sugar and water.A little artificial food may be administered if the infant be very robust and greedy,but this is seldom required.If at the end of the two days there is no milk,the child should be fed by hand until it appears,but at the same time be regularly applied to the mammary gland,which also may,if necessary be stimulated with the pump.Some mothers do not perform nursing properly or regularly because they do not realise the great importance of the act;others because the matter is left to the nurse who,after two or three trials,states that the mother is incapable of breast-feeding the child.The mother should be encouraged to do her utmost to feed the child naturally,despite such assertion;for her mental attitude may have much to do with the secretion,so that,if she becomes convinced that she is incapable,there may be an actual inhibition of the flow.But,if she be encouraged and the breast regularly stimulated,in the vast majority of cases the milk will come to the surface sooner or later.Though it is desirable to weigh the infant at regular intervals,this should not be done in the mother's presence if the balance gives unfavourable results,for loss of weight or stationary observations may have a markedly unfavourable effect upon the secretion of milk.Sometimes breast feeding is a failure because the mother does not know how to handle the infant during the act,so that precise directions should be given,especially in the case of those confined for the first time.In the first place,the mother should be taught how to put the infant into as comfortable a position as possible and draw its requirements with a minimum of effort.Its head and shoulders should rest on the arm corresponding to the breast to be drawn, and the mother's other arm should reach over the infant's body so that the hand can support its back.This is much more easily done when the mother is sitting up;but during the early days of the puerperium she is,of course,

on her back in bed.At this time a small pillow,placed under her elbow,is of great service in supporting the weight of the infant;and when she is able to be up,she should use a chair with arms on which she can rest her elbow,or upon which a pillow or cushion can be placed at meal-times.It is very desirable that the infant should come to understand that it is to commence sucking as soon as it is put to the breast;and it should continue to suck vigorously,with short rests for breathing,until it is full - when it should be forthwith taken away and laid to rest.A baby that dawdles at the breast,or one that is fretful and peevish,either is not hungry or there is some fault with the milk,the nipples,or with its ability to suck.In any case,such a child should be taken from its mother's arms as soon as a fair trial shows that it is not going to feed properly;for it is the worst possible policy to keep a crying child at the breast for a long time when it is obviously unwilling or unable to take its food therefrom.It should be kept away for some time or until another feeding comes round,when it will probably have learned what is expected of it and do its duty forthwith.But if it still refuses,the cause should be carefully sought;it may be found that there is disease,that the quantity or quality of the milk is at fault,or that there is something wrong with the nipples. To these points immediate attention should be given.During feeding the mother should with her free hand grasp the breast near the nipple between the first two fingers.If,owing to the free flow of milk,the child takes too much of the latter,this may be checked by slight pressure of the fingers.It will generally be found that the milk from one breast will be enough for a very young infant,in which case alternate breasts should be used for each nursing;but as the child grows older it will be necessary to put it to both breasts at every feeding. There is no harm in doing this at any time,provided the milk of one breast alone does not seem to be in sufficient quantity to satisfy the nursling;when satisfied, the infant usually falls asleep at the breast.The average duration of each breast feed is from ten to twenty minutes.If the milk is taken too rapidly,vomiting may ensue immediately after or during feeding;but vomiting must not be confused with regurgitation,which is a purely normal process by means of which the stomach gets rid of an overload of milk.Vomiting is always accompanied by the symptoms of nausea.It may occur at any time, but usually long after nursing.The child cries,grows pale,and even blue,about the mouth,develops a cold sweat on the forehead,and,with more or less effort,expels a quantity of sour malodorous,curdled milk from the stomach.This process may be repeated at frequent intervals, and the child is apparently sick.Regurgitation,however, occurs immediately after nursing and at no other time. The infant is bright and happy,and merely opens its mouth and allows the excess of milk to run out on its dress.In short,it is nothing more than an overflow,and, far from being injurious,is beneficial by relieving the dilated stomach.The milk is not sour and the infant is free from disease.If the child takes longer than half an hour over its feed,the breast amd milk should be examined.As it grows older it requires more food and takes longer over feeding.In time it will come to enjoy regular meals,the intervals between which should be

lengthened as age increases.It should be hungry as each mealtime comes round,satisfy itself in at least twenty minutes,and at the end of each meal lapse into calm repose.As many attacks of dyspepsia,colic and diarrhoea are due to improper nursing,the inculcation of good nursing habits is of the utmost importance;when good habits are once established,there is usually very little trouble, the success of the training depending largely on the manner in which it is dome.Regular hours for feeding should be fixed and adhered to;and if the child is asleep at the feeding hour,it may be aroused;for it will almost invariably go to sleep after its has drawn the breasts. After the last meal,which should take place usually from nine to ten at night,the infant should be coaxed into slumber and be allowed to sleep as long as it likes.During the first month or so the child will usually wake up between one and two in the morning,and again about four or five.After two or three months it will require but one nocturnal feeding,and it will sleep all night without requiring nursing after it is five months old. The infant should be give a little warm water from the bottle,but not be taken up,when the change in feeding hours is made.Regular nursing habits induce regular action of the bowels and sleep;and the three combined insure health and comfort not only for the child,but for its mother as well.The child,thus trained,should sleep without rocking or coaxing;but it may not do so if it is hungry,has wet napkins or lies in a noisy undarkened room.The occurrence of colic may be due to overfeeding,too frequent feeding,and the like,calling for immediate correction.The following table,taken from Holt's "diseases of Infancy and Childhood"is very useful as a guide to breast-feeding,and a copy of it should be in every mother's hands:

Age.	Number in twenty-four hours.	Intervals during day.	Night nursing between 9 P.M. and 7 A.M.
1st day	4	6	1
2d "	6	4	1
3d to 28th day ...	10	2	2
4th to 13th week .	8	2½	1
3d to 5th month ..	7	3	1
5th to 12th " ..	6	3	0

Another useful scheme is the following,which may be amended according to special indications:

First two days:
Every four hours.
Third day to sixth week:
2, 6, 8, 10, 12 A. M.
2, 4, 6, 8, 10 P. M.
Six weeks to ten weeks:
2.30, 7, 9.30, 12 A. M.
2.30, 5, 7.30, 10 P. M.
Ten weeks to four months:
2.30, 7, 10 A. M.
1, 4, 7, 10 P. M.
Four months to nine months:
7, 10 A. M.
1, 4, 7, 10 P. M.

It goes without saying that different mealtimes may be selected with the same intervals betwen;but the hours above displayed are those which are least likely

to interfere with the meals and other affairs of the home.I have found it of great convenience to adopt the same feeding hours for all infants coming under my care, and by this plan I have usually been able to obviate the possibility of confusion or misunderstanding as I pass from one household to another.Sickness or malnutrition will,of course,call for amendment of these rules. Sometimes the infatn appears to be hungry between meals, whereas it is only thirsty;it should be given sips of warm water until its thirst is quenched;there is no danger of its taking too much,so it should be allowed to drink as long as it likes of this liquid.Adoption of such feeding hours as those mentioned above is necessary as the infant requires nearly two hours in which it digest its food;and if it is fed too often,one meal will be taken into the stomach before the preceding one is digested,with the result that vomiting and indigestion will occur.As the infant grows older it takes more milk at a time,and a longer period is required for the digestion of this,so that the intervals between the meals must be lengthened.The great thing is to give its meals far enough apart to allow the stomach to have a short period of rest before it is put to the breast again.The infant should,moreover,never be played with or stirred up soon after a feed;for such excitement will probably interfere with digestion and cause vomiting and other dangerous things.Indeed,a child should never be played with until it is over six months of age,but be allowed to devote its entire energies to feeding,sleeping and tissue building.A good general plan is to feed the child according to the age to which the weight corresponds,the weight being the bext index of its nutrition.During the first four months it may be weighed twice a week;after that time once a week only.The average minimum gain for an infant is four ounces a week.If the weight falls below this for several weeks consecutively,it is evident that some abnormality is present and in seriousness proportionate to the loss of weight observed.

Quantity and Quality of Milk.

There is usually some fault in the quantity or quality of the breast milk when,after the exercise of every precaution,the milk does not agree with the child,it perhaps becoming fretful,gains slowly or not at all,or presents other abnormalities.In these cases the feeding is perhaps continued for over half an hour without satisfying the child,or it may draw the breasts for a minute or two and then refuse to suck because the supply is so small.Where the breast milk is nearly normal in quantity and in quality,certain measures must be adopted to augment the supply and enrich the quality,or it may be supplemented by artificial feeding.When the milk is very poor in quality,as,for example,when the specific gravity is from 1.015 to 1.025 and when only two or three per cent.of cream is present,the infant should be weaned at once,as there is no treatment to correct this.If the milk is deficient in quantity and the child is not receiving enough nourishment,it will wake before its regular feeding time and appear to be very hungry.It will cry and fret,refuse water with apparent disgust and at the earliest opportunity make a vigorous attack on the mother's breast.It will continue to suck long after the breast is empty,in its effort to

secure enough food,and will cling to its mother and cry in a fretful way when an attempt is made to remove it from her arms.It does not drop the nipple of its own accord after the normal twenty minutes' satisfaction.The breast itself,when examined just before the feeding time, will not be found full of milk as it should be;and on prolonged manipulation it will be impossible perhaps to force out any milk from the nipple.It should exude in fine jets from the firm and tense glands.Further,the infant's weight will fall off and its temperature will rise perhaps.When the milk is of proper quality but deficient in quantity,the supply may be promoted by massage of the breasts three times a day from five to ten minutes.A good extract of malt may be given with the meals, and fresh air and exercise insisted upon.The mother's general health should be inquired into,and she should be protected from worry,grief,excitement,overwork or other debilitating factors.If coffee be includedin her diet,it should be stopped entirely;for this liquid has a decided tendency to diminish the secretion of the milk.She should be allowed to drink plenty of milk or cocoa,and between meals extra milk may be allowed,as well as before retiring at night.It must be remembered,however, that too much milk is apt to upset the stomach,especially in certain individuals;and lime water should be added to each glassful as a preventive against this form of gastric anomaly;actual indigestion calls for immediate abandonment of the liquid in question.It is generally believed that certain articles increase the quantity of milk to a great extent,and amongst these mention may be made of beets and all kinds of shellfish,especially crabs.But crabs and similar rich foods should never be given to the mother while she is still in bed;and only in special cases should any of the galactagogues be administered.Too rich milk calls for a limitation of the mother's diet,especially as regards flesh-meat;all alcoholic beverages and malted liquids must,of course,be prohibited.Walking exercise,short of actual fatigue,is very useful in these cases.Deficiency in quantity and poorness in quality will call for such measures as massage,malt,also iron if there be anaemia. The diet should be simple and ample,and also contain an abundance of proteid material.A liberal amount of milk should be allowed with meals,between them,and on retiring at night,with or without dilution with lime water or plain water.Gentle exercise and rest are very important in these cases;she should not be allowed to have the care of the infant during the night.Weaning is usually indicated when the quantity is sufficient but the quality poor.The use of the feeding bottle in these cases calls for careful consideration.The advantages of early adoption of the method when indicated arethat the infant becomes accustomed to the method,with the result that there is little trouble if it has to be entirely weaned.But if the infant has taken nothing but the breast,it may often refuse the bottle entirely,with disastrous results,severe cases of marasmus being induced in this way.The method facilitates weaning,and if the mother is weak,it allows her to obtain the all-important night's rest.Better-class women are apt to wean their infants very early for the avoidance of interference with their social diversions;and so,if

the breast feeding be supplemented by the bottle-plan, many of these ladies may be induced to nurse their children during the greater part of the first year and avoid handing them over entirely to the nurse at an early age. The part-breast and part-bottle method is particularly indicated also when the mother's milk is poor or scanty, owing to some intervening illness or when, owing to deficient quantity, the mother can not entirely suckle the child; it is also useful in weaning, which is accomplished with less discomfort to the mother and child if done gradually. If the mother is suckling her infant but once or twice a day, her milk may become very poor, the infant being usually satisfied after a bottle-feed but not after the natural act. The hours for feeding, according to the age of the child, are in this method of mixed feeding the same whether the infant is at the breast or on the bottle; and if the mother has not enough milk to satisfy the child at every feeding, she can often miss one or two nursing hours and give modified milk instead of the omitted breast meals. It being better for both mother and infant to have the breast milk utilised as far as possible, this method should always be tried when the quantity of maternal milk is below normal and its quality is good. The modified milk to be used in mixed feeding is prepared in the proportions suited to the age of the child and given in the same quantity that would be allowed if the infant were to be entirely bottle-fed.

Chemical Constituents.

For the proper feeding of infants, with a view to the prevention of rickets and other ailemts, the nature and importance of these must be understood. The milk of a nursing woman is a natural emulsion, and it is composed of approximately thirty-seven per cent. of solids and eighty-seven per cent. of water; these solid substances are the fat, the sugar, the proteids, and the salts. The last-mentioned seldom undergo any appreciable variation, and are therefore of much less importance than the others; these salts are in a state of organic combination, calcium and phosphorus being in combination with casein. From the standpoint of rickets the calcium is important, as it provides the lime which is so necessary to the formation of bone. A deficiency of casein will mean a similar faultiness in calcium, phosphorus and iron, and the result of feeding on such a milk will be a strong predisposition to rickets. The proteids of milk constitute the curd, the fat is on the cream, and the sugar exists as lactose or milk sugar. Maternal milk may be tested by means of the apparatus devised by Holt, which consists of a lactometer and a cream guage. The specific gravity and the amount of cream may be readily estimated in this way. The milkf for examination should be taken from the middle of a nursing, and out into one of the glass cylinders of the apparatus with the pipette to zero mark. If specimens from both breasts are to be examined at the same time, both glasses should be used. The latter are securely corked and placed at a temperature of seventy degrees F. for twenty-four hours, after which the cream line will be distinctly visible and the percentage read on the scale. The estimation of the quality of human milk can be made by reference to and comparison with some such table as the following:

	Specific gravity 70.F.	Cream, twenty-four hours.	Proteids.
Normal average.....	1.031	7 per cent.	1.5 per cent.
Healthy variations.	1.028 - 1.029	9-12 "	Normal(rich milk).
" "	1.032 - 1.033	5-6 "	Normal(fair milk
Unhealthy "	Below 1.028	High(above 10 per cent.	Normal or slightly below
Variations	Below 1.028	Normal(5-10 per cent.).	Low.
Variations	Below 1.028	Low(below 5 per cent.).	Very low (very poor milk.
Variations	Above 1.033	High.	Very high (very rich milk.
Variations	Above 1.033	Normal.	High
Variations	Above 1.033	Low.	Normal or nearly Normal.

The proteid is required to replace the nitrogenous waste of the tissues, and a shortage of it will give rise to malnutrition. The carbohydrates and fat in the milk assist its action and lead to the maintenance of the body-heat. According to Munk(Cited by Holt,- loc.cit.), twenty-two parts of proteid can do the work of ten parts of fat, but only a half or two-thirds as much proteid are needed if fat and carbohydrate are also present. The casein and albumin of milk contain the proteid, the proportions of the latter differing in the case of the human subject and the cow as follows:

	Woman	Cow
Casein	0.59	2.88
Albumin	1.23	6.53
Total Proteid	1.82	3.41

If the proteid in maternal milk is deficient in quantity, the entire development of the child is retarded, it being late to walk, cut the teeth, and more or less anaemic and dyspeptic. If continued, rickets sooner or later occurs. The amount of proteids in the milk will vary with the specific gravity of the latter and in direct proportion thereto. Therefore, if we known the amount of cream in the milk, the proteids may be easily estimated therefrom as described. In carry out the analysis it is important to avoid handling the milk unduly; and the various appliances must be kept scrupulously clean, lest the milk turn sour before the cream has had time to rise. The sample should be allowed to stand six hours longer before the percentage is recorded if, at the end of twenty-four hours the cream line is not sharply defined. Good maternal milk contains, roughly, four per cent. of fat, seven per cent. of sugar, and two per cent. of proteid. This constitutes the entire thirteen per cent. of solid material; but, as a matter of fact, the true proportions are slightly less than these figures, leaving room for salts in small proportions. The mother's milk as it leaves the mammary gland is

sterile and absolutely free from microorganisms, blood-corpuscles or pus cells. It should have an alkaline, possibly neutral, but never an acid reaction; and its specific gravity should be from 1027 to 1032. Colostrum cells should be absent after the twelfth day, and the fat cells should be small, uniform and plentiful. The fat bears a close relation to the proteid, it sparing the nitrogenous waste and allowing the proteid to devote its energies to tissue-building. It is therefore a proteid sparer and preventer of malnutrition, as deficiency of fat calls for expenditure of the ill-spared proteid for the supply of body-heat. The fat aiding the absorption of inorganic salts, especially the earthy phosphates, from the intestines, is not without influence also on osteogenesis; the proof of this lies in the fact that a diet deficient in fat leads to the passage of these salts in the stools of the child, who therefore should have a fat-abundant nutriment. We are told that an infant under eighteen months of age requires from thirty to forty-five grammes of fat and from sixty to sixty-five grammes of carbohydrate, as exists in milk; whereas an ordinary man needs fifty-six of the former to five hundred of the latter, i.e., a proportion of one to nine instead of the one to two just mentioned. During the twenty-four hours an infant needs thirty to forty-five grammes and the adult fifty-six grammes of fat, which means that the former individual requires from half to three-quarters as much of that substance in its daily dietary as the latter. But, it must be remembered that the infant does not need so much starch as the adult, the quantities, in tabular form being as follows:

	Proteid	Fat	Carbohydrate
Infant (1½ years).....	20-60	30-45	60-90
Man (moderate work).....	118	56	500

(Figures represent grammes.)

The proportions of proteid to carbohydrates are as hereunder:

20	-	60	or	1	: 3	infant.
118	-	500	"	1	: 5	adult.

In infant feeding the following proportions of proteids, fats and carbohydrates should be secured:

Proteid.....	1.5 per cent.
Fat.....	3.5 "
Carbohydrate.....	6.5 "

In the milk from the breast of a healthy woman these conditions will be found to obtain. The fat, being the lighter part of the milk, can be accurately determined by examination; it tends to lower the specific gravity of the specimen, so that the more fat present the lower the specific gravity. But the higher will the latter be the greater the amount of proteid, as it is the heaviest constituent of this liquid. From this it follows that, if both fat and specific gravity are high, the proteids must also be high, or the amount of fat will lower the specific gravity; if the fat is low and the specific gravity high, the proteids are probably about normal, the high specific gravity being due to the small amount of fat in the specimen; if the fat is high and the specific gravity low, the proteids are again probably about normal, the low specific gravity being due to the large amount of fat; and, if both fat and specific gravity are low, the proteids must also be low, as otherwise the small amount of fat would raise the specific weight of the

specimen examined.Some form of dyspepsia will be produced by any markedvariations in the proportions of fat and proteids and the presence in the milk of such foreign materials as pus and blood.The most common form of disturbance is that due to an increased percentage of proteids,and is evidenced by constipation and the presence of curds in the stools.If this be not at once relieved,the child may lapse into a serious condition.Excessive fat occasions vomiting and diarrhoea.In view of the fact that the proteids,being the curd of the milk, would,if in excess,naturally cause curds in the stools, and that the fat,being an oil,would,if excessive,lead to diarrhoea,it is not difficult to remember these two sets of symptoms.There is an increase of both fat and proteids from a diet largely composed of animal food, but a diminution from one composed largely of vegetables. In cases where proteids are in too great amount,one may be able to correct it by prescribing the mother a vegetable diet and then,if necessary,making up the deficiency in fact by suitable doses of cream.The milk proteids are increased by such factors as fright,worry,pain and various kinds of shock to the nervous system.The same occurs from menstruation,but this increase is mainly due to the amount of pain which the mother suffers from the performance of the function.Some writers held that lactation should be prohibited on the occurrence of menstruation;but it is a better plan to determine the point from the amount of pain experienced,there being no need for interruption of nursing if it is not excessive and the milk undergoes no proteid change.Menstruation is soon over and the infant will probably take no harm from the extra call upon its digestive functions at this time.It should never be allowed to suck at a breast the milk of which contains pus or blood.Should the mother become pregnant during the period of lactation,there will be a marked decrease in the percentage of fat in her milk.It is another positive indication for the total abandonment of nursing,because the milk is not good for the child,there is too great a deman upon the mother's strength,and abortion may occur from the reflex association between the mammary glands and the uterus.

WET-NURSING.

It is sometimes necessary to call in the services of a wet-nurse if the infant is not thriving on its mother's milk,if she cannot suckle,or if the milk is deficient or absent.In certain foreign countries there are agencies for these persons,but not in our own.As a rule,only affluent families can afford such luxuries. In theory the wet-nurse is the best substitute for the mother,but in actual practice it is not infrequently found that it is better to adopt mixed feeding or the artificial plan;in short modern improvements in infant feeding have largely abolished the demand for the wet-nurse.Further,she is expensive,difficult to secure,and usually she is of peculiar temperament and a disagreeable person to have in the house,causing trouble with the other servants and making herself generally unpleasant in her assurance that the family will put up with anything rather than dispense with her all-important ministrations.Wet nurses are also undesirable inmates of a refined establishment in view of the fact that they are mostly single women secured from some public

maternity hospital,as women with homes and husbands are not likely to neglect their own children in this way, ans she is usually of bad moral character.Apart from such factors as these,an unmarried woman usually makes the best wet-nurse,not only because she parts with her own infant with little or no regret,but she has no husband to appear at frequent intervals and demand her wages or upset the entire husband by threatening to take her home again.Even a married woman who has lost her infant by death is less desirable,as a rule,for her gried will usually increase the proteid instituent and spoil her milk for dietetic purposes.Therefore,the single woman should be given the preference,it being so necessary to secure a good food for the infant without any regard to other harmless considerations.Some mothers seem to object to the employment of a wet-nurse on the ground that the infant will acquire the character and disposition of that frequently undesirable individual;the best answer to this objection is that the probabilities are exactly the same as that a bottle-fed infant will acquire the manners and morals of a cow,milk being simply a nourishing liquid and nothing else:the source of the supply from this standpoint being immaterial.It is very important that thr wet-nurse be carefully selected.She should be a primipara,in good health and free from syphilis,tuberculosis,and other affections.She should have sound breasts and well-developed nipples.Large breasts may be due to fat alone;but the breast of a good nurse should be hard and glandular after nursing.The age of the woman should be from twenty to thirty years,and the age of her child should be about that of the infant she is called upon to nurse.Her own infant should be examined;if it is healthy and in good condition,it is proof that her milk is good.Her diet should be suitable and include a certain amount of vegetable material,but alcoholic drinks had better be avoided.During the period of her engagement the general directions governing the feeding must be the same as when the infant nurses at the breast of its own mother.The quantity of milk given should be determined by the size of the breast before and after nursing or by weighing the infant at those times.The woman chosen should be one who has suckled her own child successfully for at least a month.If the infant's condition permits,the wet-nurse should be given at least a week's trial,for often the change in her mode of living may cause a scanty flow of milk or render it otherwise unsatisfactory;when she has become accustomed to her surroundings,the milk may become quite normal.Owing to idleness and a too liberal diet the milk may become too rich;in these cases the correction of the defect must be performed.

ARTIFICIAL FEEDING.

The subject of artificial or bottle feeding is a vast one,but will here be considered as briefly as possible and in its possible bearings upon the prevention of rickets.

GENERAL CONSIDERATIONS.

When for some reason or other a mother is entirely unfot to nurse her infant,artificial feeding must be resorted to.It then becomes necessary to supply a food the constituents of which as nearly as possible resemble those of maternal milk in every respect.It must also be digestible and easy of assimilation.One must always

bear in mind that there is a constant nitrogenous waste going on, calling for continual repair; and it must not be forgotten also that the infant's digestive organs are very delicate and that a catarrh may be easily excited and pave the way for rickets or other affections. The nature and composition of milk must be thoroughly understood, in order that it may be adapted to the conditions of the child. In this country the most suitable liquid for artificial feeding is cow's milk, and the ways in which it differs from that of the human mother must be known, not forgetting, however, that while general deductions may be made and average figures given, the element of personal equation must be considered a law unto itself. Children living in the country and the smaller towns, where there is no overcrowding and where an abundance of fresh air can be had, seem to thrive on cow's milk that has been modified merely by the addition of water in various proportions. In the larger towns, where overcrowding is frequent and fresh air and sunlight are not easily secured, the question is more difficult of solution; children with these environments require a more exact milk mixture and additional care. Further, in the country milk is generally obtained more or less pure and fresh, whereas in the town it is often contaminated by dirt and bacteria, and chemicals are sometimes added when it has to be sent long distances by rail. Jacobi seems to have been the first to suggest adaptations of milk to infantile requirements by the addition of such substances as barley-water or oatmeal-water. Liebig suggested that a malted, dextrinised meal be mixed with the milk. Meigs employed a milk mixture that is still used in infant feeding. Bierdert, Cheadle, and others have made suggestions; but the method in most common use perhaps at the present day is that of percentage feeding, which, hailing from across the Atlantic is called the American method. It was believed that the milk should be made to correspond in the percentage of its various elements with that of human milk, and this was the basis of the method in question. There are, however, several difficulties to overcome, it being found necessary to commence with percentages below those usually found in maternal milk and increase them with augmentation of the infant's digestive powers. Various authorities have advised the milk of the goat; for that animal is cleaner than the cow, its faeces being hard and not pultaceous; it is easy to feed and groom; there is little chance of its becoming tuberculous; and its milk is easier to digest as it has a more flocculent curd, the fat is finer, and both it and the casein closely resemble the maternal composition. The percentage composition of the milk of the goat is proteid, 3.8; carbohydrate, 4.3; and fat, 5.2. On the other hand, we have the disadvantages that it is usually very difficult to secure a suitable goat and that it is very expensive. In certain cases the milk of the ass has advantages in that the curd is very fine, that the fat is small, and that it has a somewhat aperient action. The percentage composition is proteid, 2.7; fat 1; and carbohydrate 5.3. But it is difficult to obtain and is suitable only as a temporary food to meet special indications, such as the indigestibility of cow's milk. The latter must therefore be considered as the almost universal substitute for mother's milk.

NATURE, VALUE AND USES OF MILK CONSTITUENTS.

Careful study of the nature and composition of the milk employed will alone determine the necessary adaptations for the particular infant.Fresh milk will generally affect both red and blue litmus paper,and is therefore amphoteric,though it is sometimes alkaline.The reaction is always acid,however,with phenolphthalein; and it soon becomes acid on being allowed to stand.According to Richmond(Dairy Chemistry,1899),the specific gravity of cow's milk(mixture from herd)is seldom less or more than from 1030 to 1034,the average being 1032. Leeds,however,places the figure at 1039.7,and Klimmer at from 1027 to 1040 at fifteen degrees C.Richmond says that the specific gravity of the milk depends upon the amount of solids not fat,which,being dissolved in water, raise the specific weight,and the fat which,being lighter than water,lowers the same."By removing"he finds, "the fat as cream(with a small proprtion of the other constituents),the specific gravity of the milk is raised.By the addition of water,the specific gravity is lowered.The specific gravity has been,and is,largely used as a test to show the addition of water to milk;for the detection of large amounts of water in milk it has some value.As a preliminary test,estimating the specific gravity is of the greatest importance and should never be neglected;as an absolute test,it is liable to be greatly misleading.This is shown by the following facts.I. With milk of 1034 specific gravity at least ten per cent. of water could be added before it would be suspected by this test.II.If the cream were all removed from a milk of 1032 specific gravity we would have a product of about Lo36 specific gravity,and an addition of rather more than ten per cent.of water would bring the specific gravity back to 1032.III.If to milk of 1032 specific gravity sufficient cream be added to raise the percentage of fat four per cent.,the specific gravity will be found to be about 1028."The milk of one cow,so long regarded as best for bottle feeding,is no longer used. It used to be thoughtthat one cow's milk was less liable to change than that from mixed milkings;but it is now known that while the milk from a herd preserves a very constant average of quality,that from one cow is always subject to considerable change and contain injurious products which the mixed milk will largely dilute and weaken.

Composition.

Proteids,fats,carbohydrates and mineral salts are contained in milk,the proportions of these varying according to circumstances.It may be defined as an aqueous solution of lactose,albumin and certain salts, holding in suspension globules of fat and containing casein in a state of semi-solution,together with mineral matters.Under normal circumstances it contains from ninety to eighty-four per cent.of water,varying with the quality of the liquid examined.It is suitable for feeding children,but for adults it is too rich in fat and proteids.English has analysed two hundred thousand specimens and finds the average cow's milk to contain:

Constituent.	Per cent.
Water	87.10
Fat	3.90
Lactose	4.75
Casein	3.00
Albumin	0.40
Ash	0.75

During an experience of twelve years with one of the largest dairy companies in existence, the Aylesbury, Veith estimated the lactose, proteids, and ash in milk as being in the respective proportions of thirteen to nine to two; and this would appear to agree with the findings of numerous other observers. Abnormal milk may vary greatly in composition, e.g., fat from 2.79-10.5%; lactose from 1.91-4.66%; proteids from 3.35-4.58%, and ash from 0.76-0.94%. The milk of different animals also exhibits considerable variations. Maternal and cow's milk have the same fuel value, though the former is richer in sugar and less in proteid than the latter. The milk of the canine bitch is the richest of all, and that of the mare the poorest; the following table by Koenig (Chemie der menschlichen Nährungs und Genussmittel, Vol. i, Ed. 3, pp. 267-362) will demonstrate this:

Comparative Composition of Various Kinds of Milk.

KIND OF MILK	WATER	TOTAL SOLIDS	TOTAL SOLIDS						FUEL VALUE PER POUND
			PROTEIN			FAT	CARBO-HYDRATES (MILK SUGAR)	MINERAL MATTERS (ASH)	
			CASEIN	ALBUMIN	TOTAL PROTEIN				
	%	%	%	%	%	%	%	%	Calories
Woman	87.4	12.6	1.0	1.3	2.3	3.8	6.2	0.3	319
Cow	87.2	12.8	3.0	0.5	3.5	3.7	4.9	0.7	313
Dog	75.4	24.6	6.1	5.1	11.2	9.6	3.1	0.7	671
Ewe	80.8	19.2	5.0	1.5	6.5	6.9	4.9	0.9	503
Buffalo	81.4	18.6	5.8	0.3	6.1	7.5	4.1	0.9	506
Cat	82.1	18.9	3.1	6.0	9.1	3.3	4.9	0.6	400
Goat	85.7	14.3	3.2	1.1	4.3	4.8	4.4	0.8	365
Llama	86.5	13.5	3.0	0.9	3.9	3.2	5.6	0.8	312
Ass	89.6	10.4	0.7	1.6	2.3	1.6	6.0	0.5	222
Mare	91.5	8.5	1.2	0.1	1.3	1.2	5.7	0.3	180

The changes in the percentage composition of of cow's milk may be due to such factors as the breed and condition of the animals and the nature of their food and housing. One usually finds that a young cow gives better milk than an aged one, and that a well nourished animal has a richer milk than one which is kept short of proper food. Though the cow gives the largest amount of milk shortly after calving, the secretion is richer as the supply shortens with the lapse of time. Edsall (Pediatrics, Vii, 1899), in a series of examinations, found that there were daily variations in the proteid constituent from 2.7 to 4.1 per cent. He noted this, even in winter when the animals were regularly fed; and in the spring, when the cows exicted mainly on grass from the fields, the daily variations were so great that calculations based upon any fixed percentage of proteids were liable to give very uncertain results. The proportion of proteids was below the recognised four per cent., and the fat varied from 3.2 to about 6. It is desirable that the milk supplied to the child should be occasionally analysed for the detection of adulteration. Apart from the iniquity and illegality of this, it is said, common act, the vendor may use water which is contaminated; if the water be pure it will have merely the effect of alte r-ing the proportion of constituents. The police-court reports in the daily papers show that another common form of adulteration is the removal of the fats, the

increase in the specific gravity occasioned in this way being rectified by the further addition of water and of preservatives which may or may not be of unfavourable effect in themselves.The colostrum is poor in carbohydrate,its fat is scanty in volatile acids,and the proteid is unsatisfactory.Therefore,milk should not be used for at least four days after calving - better a fortnight, when the normal composition of the liquid is attained. With the advance of bovine lactation events are just the opposite of the human case;for there is in cow's milk decrease of the sugar and increase of the fat,casein and salts.British analysts have adopted the following standard for cow's milk,viz.,three per cent.by weight of fat and eight and a half per cent.by weight of solids not fat.Veith says that during the winter and spring of a year following a bad hay season there is nearly always a poor quality of milk obtained from cows;and that both the quality and quantity of the liquid suffer after long spells of cold and wet or of heat and drought.For the mixed milk of a whole herd of cows a limit of three per cent of fat is reasonable;and it is no uncommon thing to find that there may be less than eight and a half per cent.of solids not fat.As a rule,it is safe to adopt the triple standard of 8½% solids not fat,0.5% total nitrogen,and 0.70% ash.The findings of Langlois(Cited by Cautley,- Infant Feeding),Soxlet(Kinderh.in Einzeldar., Wien,1899),and Leeds(Amer.Jour.Med.Sci.,1895,No.110) are given in the following table:

Percentage Composition of Milk.

Constituent.	Langlois.	Soxhlet.	Leeds.
Fat	4.0	3.69	3.75
Sugar	5.0	4.88	4.42
Proteids	3.4	3.55	3.76
Ash	0.6	0.71	0.68
Total Solids	13.0	....	....
Water	87.0	87.17	....

The breed of the cow has a considerable effect upon the composition of the milk obtained.Thus,Gordon has examined one hundred and forty thousand specimens of milk from various breeds,and with the following results:

Constituent.	Durham.	Ayrshire.	Holstein.	Jersey.	American grade.	Common native.
	%	%	%	%	%	%
Fat.....	4.04	3.89	2.88	5.21	4.01	3.69
Sugar.....	4.34	4.41	4.33	4.52	4.36	4.35
Proteids..	4.17	4.01	3.99	3.99	4.06	4.09
Ash.....	0.73	0.73	0.74	0.71	0.74	0.73
Water....	86.72	86.96	86.06	85.57	86.83	84.14

Holt(loc.cit.),who in his estimation disregards Jersey milk,finds the average composition of cow's milk as follows:

Constituent.	Percentage.
Fat	3.50
Sugar	4.30
Proteids	4.00
Ash	0.70
Water	87.00

Our author does not believe in selecting any particular breed for infant feeding,and thinks that as fat is the most variable constituent,the estimation of its amount is quite sufficient in the vast majority of cases. A really good cow's milk,according to Leffmann,should be composed of the following parts:

Constituent.		Percentage.
Fat	from	3.5 - 4.5
Sugar	"	4.7 - 4.9
Proteids	"	3.5 - 3.8
Ash	"	0.7 - 0.8

The figures just cited show certain variations. Richmond's are reliable owing to the large number of analyses they cover. Holt's tabulations differ from his in the higher percentages of proteids. The tabulations of Soxhlet, Leeds, and Langlois are useful for comparison, though I could cite many others did space allow or were it desirable, which it is not in view of the fact that no two of them are identical. It must never be forgotten, however, that the milk of even large herds of cows, much more that of a single cow, is apt to vary considerably from any average accepted; this is due to the differences in the breed of the cattle, the modes of feeding the latter, the season of the year and the other things already mentioned. Moreover, it is unwise to fix an average milk composition unless a large number of specimens are examined under different conditions and by different methods; and the best average ever devised is only an average and a standard which a desirable milk should as closely as possible approach. Some authorities have recommended the use of strippings of milk in certain cases, as they sometimes contain as much as ten per cent. of fat. Harrington tabulates the composition as follows:

Variety.	Water. %	Solids. %	Fat. %	Ash. %
Fore-milk	86.66	13.34	3.88	0.85
Middle milk	84.60	15.40	6.74	0.81
Strippings	82.87	17.13	8.12	0.82

We have seen that the proteids, the fats, the carbohydrates and the mineral salts are the variable classes of constituents of milk. The value and uses of these may now be considered separately. The PROTEIDS are of greater importance than the fats and carbohydrates which act as proteid-sparers and heat-producers. "The curd of cow's milk", observes Richmond (loc. cit.), "produced by the addition of acid is found to consist of casein which is combined with phosphates of the alkaline earths. In human milk this is replaced by a similar albuminoid which is not combined with phosphates. Besides casein there is a second albuminoid called albumin. This differs from casein in not being precipitated by acids and in being coagulable by heat. Other albuminoids have been described in milk, but many of them are only decomposition products of casein or albumin, which were formed during the process adopted for the removal of other albuminoids. Evidence has been adduced of a third albuminoid, lactoglobulin. This is coagulable by heat and precipitated by neutral sulphates, tannin, etc. Rennin does not coagulate it; it only occurs in traces, and it is not known whether it differs chemically from serum-globulin. The chief characteristic of lacto-globulin is its solubility in sodium chloride solutions, even when acidified. Traces of Storches' mucoid-proteid also exist in milk, and it is possible that traces of albumose are formed during the decomposition to which milk is prone; true peptone has been proved to be absent. The casein in milk is probably in the form recently described by Picton and Linder as pseudo-

solution.This state is due to the existence of particles in solution which are not sufficiently large to settle under the influence of gravity,but which will interfere with the passage of light.They can be separated by electricity or by filtering through a porous jar.They also show that there is no sharp dividing line between crystalloids and colloids in solution,substances in pseudo-solution,and substances in suspension.In milk we have these four states represented:the fat is in suspension,the casein in pseudo-solution,the albumin in solution as a colloid,and the lactose in solution as a crystalloid.These four states are probably due to the size of the conglomerates of molecules or particles."Casein is,therefore,the principal nitrogenous constituent of milk;and it differs from other proteid compounds in that it contains both phosphorus and sulphur;it is not coagulated by heat,but this change may be brought about by the addition of acid or rennet;the clot formed by the addition of acids may be dissolved by neutralising the latter,while that formed by rennet is not affected by alkalies.In addition to the casein,there is in milk a substance called lactalbumin,which is similar to the serum albumin present in the blood.In maternal milk the proteids are lactalbumin and casein,in the proportion of two-thirds of the former to a third of the latter substance.In the milk of the cow one-sixth of the protein is lactalbumin and the remainder is casein.The total proteid of human milk precipitates in fine flakes;that of cow's milk in heavy curds.The total proteid also varies, being from one and a half to two per cent.in human milk to three and a half in cow's milk.The necessary modification consists in diluting the milk until the proteid is from about half a per cent.or more,according to the age of the child and the strength of its stomach.In some cases of difficult feeding the lactalbumin and casein may be separated and added in the required amounts. This is not,however,usually necessary.The proteids may be prevanted from forming large curds by the addition of lime-water or of barley- or oatmeal-gruel,but this is not,as a rule,required with the smaller amounts.One may predigest the proteids should circumstances demand this treatment.If the proteids in the milk are too high the infant is apt to have colic,and may vomit at any time, but usua ly half an hour or more after feeding.The stools will contain undigested curds and mucus;they may also be yellowish-green or of abnormal colour.To low proteids will produce small and constipated stools,if the other food constituents are alow,as they are apt to be. The infant does not gain in weight so rapidly as a normal child,or it may remain stationary or even lose weight.It is anaemic,and if the low proteid is persisted with,marasmus may occur.

There are various kinds of FATS present in milk, viz.,the glycerides of palmatic,stearic and oleic acids; further,there are several other fats in smaller proportions,to which the flavour of the butter is due.The fatty material of the milk is suspended in the form of minute globules,which give the milk its white colour and opacity.Fat constitutes about thirty-one per cent. of the total solids of milk,or about four per cent.of the bulk of both human and cow's milk.If the milk has to be di luted,the deficiency must be made up either by adding cream or by using the upper third or upper half of the milk after the cream has risen;gravity or top-

milk cream had better be used in these cases.According to Richmond(loc.cit.),the fat of cow's milk is by no means of simple composition."It differs from all other fats",he says,"in that it contains compound glycerides, partly built up of fatty acids of low molecular weight. The general concensus of opinion at the present day is that the fat globules in milk are not surrounded by a membranous envelope,therefore there is a true emulsion. there is very little doubt that a layer of some sort exists,probably formed by a force similar to capillary attraction.Leeds says that this layer consists of a number of albuminous molecules which have been condensed by molecular attraction and thereby hinder the coalescence of the fat particles.From the mean results obtained by different observers,the average composition of the fat of milk appears to be as follows:

	Per cent.		Per cent.		Per cent.	
Butyrin...	3.85,	yielding	3.43	fatty acids and	1.17	glycerol.
Caproin...	3.60,	yielding	3.25	fatty acids and	0.86	glycerol.
Caprylin..	0.55,	yielding	0.51	fatty acids and	0.10	glycerol.
Caprin....	1.90,	yielding	1.77	fatty acids and	0.31	glycerol.
Laurin....	7.40,	yielding	6.94	fatty acids and	1.07	glycerol.
Myristin..	20.20,	yielding	19.14	fatty acids and	2.53	glycerol.
Palmatin..	25.70,	yielding	24.48	fatty acids and	2.91	glycerol.
Stearin...	1.80,	yielding	1.72	fatty acids and	0.19	glycerol.
Olein,etc.	35.00,	yielding	33.60	fatty acids and	3.39	glycerol.
Total	100.00	Insoluble	87.65	Total	12.53	
		Total	94.84			

Our author also observes that there also exist,in addition to the above constituents,"traces of cholesterol(which doubtless replace a portion of the glycerol),lecithin, a colouring matter,and possibly also a hydrocarbon.Lecithin exists in small quantities in butter fat;on saponification it gives glyceryl-phosphoric acid,fatty acids, and choline;it contains 3.84 per cent.of phosphorus and gives 8.8 per cent.of phosphoric acid on oxidation.The quantity does not exceed 0.5 per cent.of the fat.There is also a colouring matter of unknown composition and an odoriferous principle."The fat in milk is the great proteid-sparer and the manufacturer of body-heat;it is also of service in the building up of the nervous system.The infant needs a lot of it in its food;and,according to Budin,the average ration derives fifty-three per cent,of the calories from the butter,twenty-nine from the carbohydrates and eighteen per cent.from the proteids or albuminoids.The average infant needs one hundred calories per kilogram of its weight every twenty-four hours.In rickets the administration of a proper amount of fat is clearly indicated for the rectification of the various disorders present.If too much of it be given, the infant will vomit an hour or so after every feed and maysuffer from colic.The stools may be thin or green or greenish-yellow and contain small masses of undigested fat and considerble mucous material;these small masses must not be mistaken for curds,which they markedly resemble sometimes.They are more or less translucent,and when burnt give off the odour of fatty acids;they may be dissolved in ether,but that reagent will not effect the solution of curds.In some cases we observe stools which have an odour of rancid butter and are large and white and somewhat inclined to dryness.Shortage in fat will lead to the child gaining weight slowly;and the patient is apt to be constipated unless an excess of

sugar is given as in feeding with one or other of the numerous brands of condensed milk.Though there is four per cent.of fat in both human and cow's milk,it will usually be found that the infant will do better on three of three and a half;in fact,Jacobi has found two per cent.of fat even more suitable,this quantity being contained in the well-known prescription of Strauss.On the other hand,Still(loc.cit.)is not in favour of any milk containing less than three per cent.of this substance. Holt prescribes one per cent.on the second day of the infant's existence; two per cent.when it is a week old; three per cent.at the end of three or four weeks;and four per cent.when the infant has passed the fourth or fifth month.Other writer advise that the amounts should be two per cent.the first week,two and a half per cent. the second,and three per cent.the third;at four months the amount may be increased to four per cent.,but after that time this amount must not be exceeded lest the child becomes dyspeptic and have the large whitish stools with the characteristic fatty-acid odour.In general,the amount of fat allowable varies with thr age,weight and digestive powers of the infant;and it is advisable to lower it a little during the very hot months of the year. Excess fat,in addition to causing the above disturbances, may even lead to the child becoming fat;in rickets there is frequently a fatness and flabbiness which deceives both the mother and the public who admire the photographs of the food merchants on the hoardings.Sometimes, however,the food is not at fault,for the fat may be given to excess in the form of cod-liver oil or other drugs. One must beware of invariably relieving the constipation of rickets by increasing the fat;it is better to examine the dietary and make the necessary reforms,taking care that an excess of sugar does not interfere with the digestion of the fat.Still(loc.cit.)thinks that the administration of one and half per cent.of fat in the case of a child of six months is no safeguard against rickets, and that the same is true of excess of sugar in the food. Cream is the best form of fat in these cases,and in every case it should be in due proportion to the proteid requirements.

The carbohydrates are required for the production of body-heat and of muscular energy. The principal carbo-hydrate of milk is lactose or milk-sugar,which is not nearly so sweet as ordinary domestic sugar and is less soluble in water than the latter.It gives the glucose reaction with the usual sugar tests,and in the presence of the lactic acid bacillus is converted into lactic acid and sourness of the milk results.Lactose constitutes about thirty-eight per cent.of the total solids."The sugar in cow's milk",remarks Richmond,"is said not to be identical with that in human milk.Lactose is not fermentable by ordinary yeast and is not acted upon by invertase, diastase,rennet,pepsin,and trypsin.There exists,however, an enzyme called lactase,which is found in fresh kephir grains,which hydrolyzes lactose to glucose and galactose. The bacteria which decompose lactose with the production of lactice acid are acted upon inimically by acids,so that not much more than one per cent.of lactic acid is formed unless the solution is kept neutralized".In the case of human milk the amount of sugar varies from six to seven per cent.;in the case of the cow it averages about four and a half per cent.The proportion is decreased by diluting the milk,and the deficiency thereby induced must be made up by the addition of either milk-

milk-sugar or ordinary sugar, the former, being a normal milk constituent, being the better - though Jacobi believes in the latter through its being twice the strength for sweetening of milk-sugar and much cheaper. The sugar should be in the proportion of from five to five and a half per cent. during the first few days of the infant's existence; from the second week to the third month, six per cent.,; and from thence to the eleventh month, about seven per cent. It may thereafter be reduced to five, and to four and a half per cent. a few months later. The administration of over seven per cent. of sugar is without advantage. Indeed, excessive sugar may give rise to vomiting an hour or so after meals, the vomited material usually having a sour odour; acid eructations are common; colic is frequent; the stools are generally green in colour and very irritating, the nates of the infant presenting excoriations. If insufficient sugar be given, the infant gains weight very slowly; the child is inclined to be thin, and constipation may be observed. From five to seven per cent. of sugar is therefore the range of proportion; a ready method of administration is to prepare a five per cent. solution of milk-sugar (one ounce of the latter in twenty ounces of water) and add it as required to the food.

Milk contains about 0.7 per cent. of **SALTS**, and mainly in the form of phosphates, chlorides and sulphates, the potassium compounds being more abundant than the sodium ones. They are absolutely essential for the formation of osseous tissue, and are therefore of great importance in the prevention and treatment of rachitic disease. They constitute about 0.2 per cent. of the entire bulk of milk, those of cow's milk being three or four times greater. They vary in the same proportion as the proteids, and when the milk is modified for the increase or diminution of the proteids, there is a corresponding alteration in the percentage of inorganic salts. According to Richmond (loc. cit.), there is some doubt regarding the alleged presence of citric and acetic acids in milk, though it is held that casein and albumin are present in that liquid as salts of alkalies. "Casein," he affirms, "has a peculiar affinity for calcium salts, especially the phosphates, from which it is extremely difficult to free it; nor has it been found possible to dissolve casein to an appreciable extent without an alkali being present. Milk does not become sour until appreciable acidity has developed. The phenomenon of coagulation of milk after this has occurred, and on the application of heat, is probably due to the acid developed displacing the casein from its combination with an alkali, and, when this is wholly accomplished, to the free acid manifesting its properties. The relative percentages of salts in the ash of human milk may be seen in the following table, which is based upon a long series of examination:

	Per cent.
Calcium phosphate	23.87
Calcium sulphate	2.25
Calcium carbonate	2.85
Calcium silicate	1.27
Potassium carbonate	23.47
Potassium chloride	12.05
Potassium sulphate	8.33
Magnesium carbonate	3.77
Sodium chloride	21.77
Ferric oxide and aluminium	0.37

Harrington and Kinnicutt, and Richmond tabulate analyses which show slight differences between the human and the animal secretions:

	Harrington & Kinnicutt. Ash of Mother's Milk. Per cent.	Richmond. Ash of Cow's Milk. Per cent.
Lime	15.69	20.27
Magnesia	1.92	2.80
Potash	24.77	28.71
Soda	9.19	6.67
Phosphoric acid	10.73	2 9.33
Chlorine	20.11	14.00
Carbonic acid	7.97	0.97
Sulphuric acid	2.19	Trace
Ferric oxide, &c	0.40	0.40
Silica	0.70	....
Oxygen (calculated)	6.16	....
	99.83	103.15
Less oxygen and chlorine		3.15

The ash does not actually represent the salts of milk, and for the reason that the phosphorus and sulphur of the proteids are, by oxidation, converted into phosphoric and sulphuric acids; the phosphorus of the casein furnishes about eight per cent. of the phosphoric acid present in the ash of milk. Other comparative analyses of human and cow's milk are as hereunder tabulated:

Mother's Milk. (Harrington & Kinnicutt.)	Per cent.	Cow's Milk. (Soeldner.)	Per cent.
Sodium chloride	21.77	Sodium chloride	10.62
Potassium chloride	12.05	Potassium chloride	9.16
Potassium sulphate	8.33	Potassium citrate	5.47
Potassium carbonate	23.47	Potas. phosphate	21.99
Calcium phosphate	23.87	Calcium "	16.32
Calcium carbonate	2.85	Calcium citrate	23.55
Calcium silicate	1.27	Lime with proteids	5.13
Magnesium carbonate	3.77	Magnesium citrate	4.05
Iron oxide & alumina	0.37	" phosphate	3.71
Calcium sulphate	2.25		

Though there is a larger amount of phosphorus in cow's milk than in the human secretion, only the smaller part of it is in organic combination in the case of the cow's milk, the rest existing as inorganic phosphates. But in human milk all the phosphorus is in organic form; according to Schlossmann, there is thirty-five per cent. in the casein, the same percentage in the nucleon, and thirty per cent. in the lecithin, as against thirty-five per cent. in the casein, eleven per cent. in the nucleon and lecithin, and fifty-four per cent. in inorganic combination in cow's milk. Casein may be considered a nucleo-albumin as it contains phosphorus; but whereas the nuclein present in it is not absorbed as such, nucleon and lecithin are readily absorbable. The organic preparations of phosphorus are far more important in the development of the child than the inorganic salts, the combinations of which with phosphorus, on administration with the food, give only a very slight amount of that metal. Cow's milk, as usually administered to children, has only a slight amount of casein and even less nucleon and lecithin; and the nuclein in this small amount of casein is more or

less completely absorbed.There appear to be no essential differences between cow's and human milk in the respect that nuclein and paranuclein are rendered soluble by the pancreatic ferment,they being for the most part changed into nuclein-phosphoric acid.According to Müller,the absorption of the phosphorus of cow's milk,when not supp-lied to excess,is just as complete as that of the phos-phorus in human milk,and the same has been affirmed of the casein constituent in both cases.The amount of orga-nic phosphorus and of the organic sulphur present in the lactalbumin of cow's milk is very small.There seems to be no way of making up for the greater richness of human milk in nucleon and lecithin,which increases as the milk becomes greater in amount.Boiling the milk destroys the lecithin,and the nuclein of the casein as well if the application of that agency be prolonged;and it would seem that there is also an alteration resulting in the nuclein of the casein.The occasional development of scurvy in the case of children hand-fed for a consider-able time on milk and milk preparations,which have been well heated,is thus explained;and the element of phos-phorus insufficiency in the production of rickets is suggested by the markedly remedial action of such sub-stances as phosphorus and cod-liver oil.Although the amount of salts in mother's milk decreases with the adv-ance of lactation,the infant really obtains enough nour-ishment for its osseous and other requirements,as the quantity of milk secreted also increases,of which the infant is able to assimilate more and more.

The GASES of milk are not of much importance from our present standpoint.The absorption of air during and after the operation of milking the cow leads to the presence of oxygen,nitrogen and carbon dioxide.After a while aerobic germs are introduced,and then the last-mentioned gas increases and the oxygen decreases.Accord-ing to Thoerner(Arch.f.Kinderh.,1896,Bd.20),the milk of the cow,immediately after milking,contains from fifty-seven to eighty-six cubic centimetres per litre of carb-onic acid,oxygen and nitrogen;the serum of acid milk contains even larger amounts:from one hundred and fourt-een to one hundred and seventy-two per litre;a large proportion of this gas disappears in centrifugation,and on the average from twenty-seven to fifty-four cubic centimetres remain;boiling and sterilisation still farth-er reduce the amount of gas from fifteen to nineteen cubic centimetres per litre of milk.There is an incre-ase from storage in closed bottles,this being due to the carbonic acid fermentation in cases in which the bottles are not heated as soon as they are filled.Milk steril-ised in open bottled is apt to have an unpleasant taste, which is the result not ofchemical alteration,but of the disappearance of the carbonic acid.To make it palat-able again,that gas may be artificially introduced into the milk.

Analysis of SKIMMED MILK shows that it contains from 0.4 to over two per cent.of fat,0.3 per cent.being seld-om exceeded;there is a slight increase of the other elements on removal of this substance.The milk left after the use of the separating appliance contains such inor-ganic impurities as dirt,vegetable materials from hay or leaves or other cattle food,and such substances der-ived from the cow as hair,udder epithelium,glandular cells,pus,blood,or germs.The slimy residue in which the above are contained probably is equivalent to 0.04 per

cent.of milk separated,and in dirty milk there may be 0.15 per cent.of it.Filtration of approved lines is required for the removal of all contaminations.

General Principles.

In his welleknown and oft-cited work on the "Artificial Feeding of Infants"(p.39),Cheadle certain rules,which make an excellent basis for the diet of the child in health or disease;they are to the following effect:First,the infant's food should contain the various constituents in the same proportions as human milk.Second,the antiscorbutic element must be present.Third,the total amount given in the twenty-four hours must represent the nutritive value of one to three pints of human milk,according to age.Fourth,the food must not be wholly vegetable,but be constituted of a large proportion of animal material.Fifth,the food must be such that the child's stomach is able to digest it without discomfort. Sixth,there must be neither decomposition not contamination present.Cow's milk cannot be changed into the human product,it being adapted to the requirements of the calf and not without modification to those of the child.The child should be weighed at least weekly and the stools regularly examined;in the absence of abnormalities in these respects it may be concluded that the food is of the suitable sort,particularly if the muscles are firm and without conspicuous flabbiness and obesity.In the case of the rickety child the essential dietetic point is to have a food of easy assimilation and rich in fats and proteids;but this kind of diet must not be instituted too soon,there being in these cases usually a considerable degree of gastrointestinal disturbance calling for cautious dietary according to indications.Water,white-wine whey,buttermilk,and vegetable and malted soups may be needed at this stage.Some of these substances may now be considered.

If milk be coagulated by rennin,a ferment of the gastric juice,or by lemon-juice,white vinegar,or other similarly-acting substances a curd is produced consisting of coagulable casein;after its removal a fluid portion remains,and this is whey - a desirable substitute for milk in certain cases.Its composition is dependent upon the kind of milk from which it is made,that from whose milk containing more fat than that from skimmed milk,though the soluble proteids are more or less constant. Numerous analyses have been published, of which the following are illustrative:

Composition of Whey according to Van Stykes.

	From Poor Milk. (3% fat.)	Medium Milk. (4% fat.)	Rich Milk. (5% fat.)
Total solids	6.87	6.96	7.38
Fat	0.28	0.30	0.30
Total proteids	0.69	0.87	1.03
Sugar and ash	5.90	5.79	6.04
Water	93.13	93.04	92.62

Koenig has analysed forty-six specimens and finds the following percentages:

Fat	0.32
Proteids	0.86
Sugar	4.79
Salts	0.65
Water	93.38

Monti's Analysis.

	Per cent.
Fat	1.00
Proteids:	
Casein	0.03
Soluble albumin	0.80-1.00
Sugar	4.50-5.00
Salts	0.70
Water	.....

Whey can be prepared by adding to half a pint of fresh milk, at lukewarmness, a tablespoonful of essence of pepsin, and then stirring until mixture is attained. When this is firmly coagulated, it should be beaten up with a fork until the curd is finely divided, after which it may be strained. Wine, lemon-juice or other flavouring agent may be added, if desired. Pavy prepares a cream-of-tartar whey by adding a heaped teaspoonful of cream-of-tartar to a pint of boiling water, straining, sweetening as desired, and serving vold. A wine whey may be made by cooking together a cup of milk and half a cup of sherry; as soon as the curd separates, it may be strained and sweetened, then served hot or cold. A lemon whey is manufactured in the same way as the foregoing, using three tablespoonfuls of lemon-juice instead of the sherry wine. According to Michell (Brit. Jour. Childr. Dis., iii, 36), the whey should be heated to 155. F. before the addition of cream, to prevent coagulation; above 160. F. the lactalbumin will undergo coagulation. Details such as these are likely to be forgotten in the home, and for all practical purposes the use of hot water is sufficient. Mutton broth, dextrinised gruel, egg-albumin and other food stuffs may be added to the whey, according to indications. Cloudiness of the whey would indicate the presence of some of the fat and paracasein; the proteid constituents are lactaglobulin and lactalbumin, but the presence of former may be disregarded as it is present to the extent of only one per cent. Whey is valuable in artificial feeding of infants as it enables the safe administration of proteids and a little casein when needed. It is useful especially in rickets, as it contains all the requirements for the osseous demands. The method is sometimes called that of the split proteids and commonly adopted in cases of casein indigestion. The wine whey is particularly useful in debilitated or collapse cases where a stimulant is required; it is seldom rejected even by very irritable stomachs. Still (loc. cit.) thinks that an infant should never have more than two and a half ounces of it at a time, it being better to allow it in small amounts at frequent intervals.

Pegnin is a preparation of rennin ferment and sugar which was first advocated by Von Dungern (Münch. med. Woch., 1900, No. 48), it being at present in considerable vogue in Germany and other countries. It is said to make the curd of milk more easy of digestion and softer; it may be given as it is made or diluted with hot water. Oppler (Monat. f. Kinderh., Jan., 1904, p. 530) noted its effects in a long series of cases and concluded that it is particularly indicated when, as after an exclusively starchy diet, the general conditions of the patient is unsatisfactory; in cases of gastrointestinal disturbance; and in cases of obstinate vomiting of food. On the other hand, it should not be given during the first month of the child's existence, in affections due to overfeeding,

and never for too long a time.Some children seem to do well upon it when they cannot be made to thrive on ordinary milk,as a temporary substitute for which it is excellent.To prepare it one measure of pegnin from the bottle in which it supplied is added to eight ounces of milk sterilised and cooled to 104.F.Very soon the milk forms large and soft curds,which on vigorous agitation break up into fine particles.

Certain cases of gastrointestinal disturbance do well upon vegetable and malt soups;they seem to relieve catarrhal cases and are worth a trial in rickets.Bailey (Gaz.Hebd.de Méd.Sci.,June 2,1906)speaks highly of a soup made of carrots(65 grm.),potatoes(.5 grm.),turnips (.5 grm.),and dried peas or haricot(.25 grm.),with salt (5 grm.)to a litre of water.Comby's soup is not unlike this,but contains more phosphates,sulphates,hydrocarbons,and vegetable albumins.Terrien's soup is prepared by allowing an infusion of crude malt to act,at a temperature of 80.F.,on a mixture of rice cream(70-80 grms.), cane-sugar(50 grm.),and water(2/3rs litre);and its inventor says that it is of great service when milk is not assimilated and a carbohydrate is needed,in cases of indigestion and chronic gastroenteritis for example,though it must never be given when vomiting and diarrhoea are present,or when the child is not four months old. Celery and tomatoes are sometimes used for the preparation of these soups.Malted soups or gruels are sometimes very beneficial in the case of infants with an inclination to dyspepsia.To prepare a gruel of this kind a tablespoonful of barley flour,or of any other desired flour, is boiled in a little more than a pint of water for fifteen minutes.As soon as it has cooled,a teaspoonful of malt extract,or one of diastase,is added.This mixture is well stirred,and may then be used in the place of ordinary barley-water.Diastase preparations are made by most of the well-known manufacturing chemists;maltine,etc.,are of this class.The thick malt extracts are sometimes given to infants,troubled with dyspepsia and constipation,just before meals.Chapin's home-made decoction of malt is prepared as follows:"A tablespoonful of malted barley-grains is put in a cup,and enough cold water added to cover it - usually two tablespoonfuls,as the malt quickly absorbs some of the water.This is prepared in the evening and placed in a refrigerator overnight.In the morning the water,looking like thin tea,is removed with a sppon or skimmed off,and is ready for use.About a tablespoonful of this solution can be secured and is very active in diastase.It is sufficient to dextrinise a pint of gruel in ten to fifteen minutes.This should be prepared fresh every day".Gregor(Deut.med.Woch.,Oct.6, 1893)claims to have cured no less than one hundred gastrointestinal cases with malt soups,which,after the age of three months,he continues if necessary for a considerable time;after from nine to fifteen months he found all his severe rachitic cases do very well on this diet,which seems to have certain advantages over all forms of artificial food.

Buttermilk is at present enjoying some popularity in infant feeding,especially on the continent,as a highly nutritious and digestible beverage.Its exhibition should not,however,be commenced too rapidly,lest vomiting or diarrhoea result;if gradually administered and continued,the digestion usually becomes accustomed to

it.It has also been affirmed that a reversion to sweet milk will give rise to a similar disturbance in buttermilk-fed infants,and that the change should always be made gradually,by mixing buttermilk and sweet milk together before preparing the food.It contains the casein of milk in a finely coagulated form,and,according to Pavy,its composition is as follows:

	Per cent.
Water	88.0
Nitrogenous matter	4.1
Fatty matter	0.7
Lactine	6.4
Saline matter	0.8

Schlossmann fed one hundred and fifty infants on buttermilk with good results;he added cream to the milk if there was not a proper increase in weight.Salge(Jahr. f.Kinderh.,Nov.,1905)advises buttermilk when the child is suffering from acute digestive troubles or is marasmic.It may be added to malt soup or constitute a substitute for breast milk.It must be fresh and clean and carefully prepared from sour cream.The average desirable composition is from 2.5 - 2.7 proteids, 0.5 per cent. fat,and 2.8 to 3 per cent.sugar.Seven hundred and fourteen calories are provided by one litre,according to Rubner.At one of the German hospitals one hundred and nineteen cases were fed on it,and with favourable results in eighty-five.The faeces contained many lactic acid bacilli and were of firm consistence;in some cases there was constipation.To each litre of buttermilk fifteen grammes of meal and sixty grammes or ordinary sugar were added,and it was then heated slowly to boiling.It would seem that the greater percentage of the proteids are absorbed.It has a certain potency in inhibiting the action of intestinal bacteria,and is sometimes of signal service in cases of fat indigestion,owing to the fineness of its curd.Though the low percentage of fat in buttermilk would seem to contraindicate its employment in rickets,it will usually be found that it is not without beneficial effects.Rommel(Arch.f.Kinderh.,xxxvii, 252)says that it is a marvellous food in these cases sometimes,but that there should be made an increase in its fat and a decrease in its carbohydrates as it interferes with the mineral metabolism,especially the calcium balance,if continued too long.Gregoire(Arch.de Méd.des Enf.,Feb.,1903,p.65)speaks highly of it as a substitute for breast milk;and Cardamatis(Ibid.,Feb.,1904,p.87) declares that it is unequalled in cases of malnutrition and gastrointestinal disturbance,Decher(Ibid.,Jan.,1905) is also in favour of it,for it has given him brilliant results in rickets,and has in his practice acted more or less like a specific in cases of gastroenteritis through its easy absorption.Some of the continental practitioners advise the addition of a carbohydrate to buttermilk,the preparation being then commonly known as babeure.It is prepared by adding a tablespoonful or so of arrowroot or rice or ordinary flour to a litre of buttermilk,the whole being then slowly brought to the boil during the half hour or so it is gently stirred with a wooden spoon.Eighty grammes of sugar are now added and the mixture put aside to cool;during the process of cooling there are formed two layers,the upper one clear whey and the lower a yellowish clotted cream. A bottle with a largish nipple must be used,otherwise

the mixture will not flow.Ordinary buttermilk has the great recommendation of cheapness;but if it be used for a long time,gravity cream should be added to increase the fat content.

Lactobacilline.

This is milk turned acid by the addition of the lactic acid bacillus,and was first advised by Metchnikoff in the therapy of gastrointestinal affections characterised by fermentative processes.Pure cultures of the bacterium lactis are used,the harmless Bulgarian and estern varieties preferably.The bacilli are said to convert the alkaline faeces of these cases into a substance too acid for the development of the putrefactive germs.The preparation can be obtained in various forms for homeuse,and most of the dairy companies supply this milk ready prepared at a very small extra cost.It is said to do all claimed for it,but it must be used with caution in specially slected cases.

Kephir.

This somewhat resembles the above acid milk, and has long been used in the Caucasus,cow's milk being fermented with the saccharomyces mycoderma,lactic acid fermentation proceeding at the same time.The casein is partly digested and alcohol,lactic acid,and albumins are formed as a result of the fermentative changes.It takes about twenty minutes to prepare and the liquid is not ready for consumption until the following day.The composition is: proteids, 3.8; fat, 2.0; carbohydrate, 2.0; lactic acid, 0.9; and alcohol, 0.8 per cent.It is easy of digestion and obviates intestinal fermentation.The taste is rather disagreeable,but this can be overcome by the addition of cane-sugar.

Kumiss.

This is a similar preparation manufactured by both lactic acid and alcoholic fermentation.For hundreds of years it has been used by the preople along the shores of the Caspian Sea;the milk is obtained from a special breed of mares very carefully fed.The milk is mixed with a kumiss ferment,the lactic acid ferment converting some of the sugar into lactic acid,while another part of the sugar is changed into alcohol and carbonic acid;a small amount of the casein is digested during the process.The milk must be constantly shaken up and the fermentation allowed to operate until the next day. The resulting liquid is acid,effervescing and contains a little alcohol;it can be easily digested,more readily than milk.The casein is so finely divided that lumps cannot be formed in the infant's stomach,and it is easily acted upon by the gastric juice.The ferment can be purchased at the druggists and the milk manufactured at home.

Matzoon.

This is a third form of acid milk in which lactic acid is produced by a Syrian ferment.It contains no alcohol and is thicker than the preparation just described,over which also it has no advantages.

These three preparations are of great service in cases which cannot tolerate ordinary milk or its usual modifications,and against them the infant's stomach does not usually rebel. Hutchinson(loc.cit.)has tabulated the composition of some of these liquids as follows:

Percentage Composition

	Proteid	Sugar	Fat	Salts	Alcohol	Lactic acid
Kumiss	2.2	1.5	2.1	0.9	1.7	0.9
Kefir	3.1	1.6	2.0	0.8	2.1	0.8
Mare's milk	2.6	5.5	2.5	0.5		
Cow's milk	3.3	4.8	3.6	0.7		
Buttermilk	3.8	3.3	1.2	0.6		0.3

Dextrinised Gruels.

These are sometimes of service in the case of infants who are unable to tolerate milk;they are temporary foods or may be used as diluents of cow's milk. Rickety cases usually do well upon them,and in most casesthey are far superior to patent foods.The claim that cereal waters have no more effect on the curd of cow's milk than plain water has been disproved,as it was based on the precipitation of casein with dilute acids and not upon its coagulation with rennet,which is what occurs in the child's stomach.To break up the curd of cow's milk and furnish a small quantity of easily absorbable food,cereal gruels,in which the starch has been converted into dextrin and maltose,are the most practical and desirable agents.Cereals appear to give the finest curd of any diluent,though it is affirmed that the effect of the cereal is lost when the starch is digested,especially if the digest ve ferment is active.The effect of a digested gruel on the curdling of milk depends on the strength of the gruel and the dilution of the milk.The very best effect,so far as the digestive effort is concerned,is obtained when the starch is completely rnedered soluble,so that the particles of proteids and cellulose of the cereals are free.As a rule,there is no need to use gruel stronger than one tablespoonful of flour to the pint for any dilution of milk;wheat,oatmeal or barley may be used.Besides acting as mechanical attenuants, these gruels possess some nutritive value,since they con-tain dextrin and maltose,which are absorbed without difficulty.For home preparation a tablespoonful of malted barley grains is put into a cup and enough cold water added to cover it.This should be prepared in the evening and kept in a cool place overnight.In the morning the water is strained off and is ready for use.The diastases on the market,or any of the thick malt extracts, may be used.A mixture of eight ounces of dextrinised wheat gruel,the white of an egg,and two small teaspoonfuls of granulates sugar gives about two per cent.of proteids and seven per cent.of soluble carbohydrates; whereas one having the yolk of an egg substitutes for the white thereof gives about one and a half per cent. of fat,the same amount of proteids and seven per cent. of soluble carbohydrates - there beinf also in the yoke organic combinations of phosphorus and iron.Criticising dextrinised gruels,Leeds(loc.cit.)says that a gummy material like dextrin or finely divided starch like that in oatmeal-water or barkey-water,along with more or less glutinous extractive matter,is much better adapted to serve as a mechanical attenuant of casein and farinaceous foods in their ordinary condition.Oatmeal contains more starch than barley-water and wheat more than either;the latter is therefore less easily acted upon by the gastric juice.For the preparation of the convenient Chapin dextrinised gruel,to one pint of gruel,- made by boiling for fifteen minutes one tablespoonful of wheat

or oatmeal or narley flour with one and a half pints of water,- add,when cool enough to be tasted,one tablespoonful,- in the case of infants a teaspoonful,- of diastase or thick malt extract.This mixture should be kept at a temperature of 150.F.for from fifteen to twenty minutes,until the gruel becomes thick and watery,which will indicate that there is complete conversion of the starch into dextrin and maltose.Virol may be used sometimes instead of the extract of malt,particularly in rachitic cases with emaciation.Cheadle(loc.cit.)has recommended a bread jelly,which may be prepared at home quite easily and convinces the mother that her infant is really having a food without the necessity of wasting money over proprietary brands.A slice of bread(our author advises seconds flour for this)should be soaked overnight in water and next morning be slowly boiled for an hour or so.The starch being now converted into dextrin and grape sugar,the mixture is strained through fine muslin and used in jelly-form when settled.Only enough for a single feed should be made,as it very soon turns sour,especially in hot weather.It makes a good vehicle for the administration of cream,meat-juice,etc.,or it may be added to other liquid preparations.To it should be added eight ounces of water,a tablespoonful of cream and sugar to taste:then the composition will approximately be fat 0.13, carbohydrate 4.15,and proteid 0.74. Meat-juice makes a very useful addition in rachitic and other debilitated cases,the quantities being the above diluted jelly five tablespoonfuls, raw meat-juice six teaspoonfuls, cream two teaspoonfuls - the resulting composition being fat 3.63, carbohydrate 2.93, and proteid 2.71.

Egg Mixture.

Egg albumin has long been used as an infant's food,though it seems doubtful that it issufficiently well assimilated to amaterially assist the nutrition of the child.Nevertheless,it seems to be useful in cases in which the administration of milk is contraindicated. It may be given mixed with water and a little salt,or added to dextrinised gruels,etc.A mixture of the white of egg with a teaspoonful or two of sugar and about eight ounces of dextrinised gruel would have the composition of two per cent.proteid and four to seven per cent. carbohydrate.If the infant cannot tolerate cream and needs fat in some form,the yolk of egg should be added to the above quantities of dextrinised gruel and sugar,in which event the composition would be one to five per cent.of fat and proteid and four to seven per cent.of carbohydrate.

Ashby's Food.

Ashby(loc.cit.)thus describes the preparation of a reliable infant's food:"Obtain a good rich milk and set it in a 30 ounce glass bottle for 5 or 6 hours at a temperature of 40.F.(ice being required for this purpose in the summer),a plug of sterilised cotton wool being placed in the mouth of the bottle.Syphon off the lower 15 ounces and replace by 15 ounces of 7 per cent.sugar-water.Pasteurise and cool rapidly.If a weaker food be wanted,replace the lower 20 ounces by 20 ounces of a 6 per cent.sugar-water.Or a quart of milk is allowed to stand in a glass jar for 12 hours surrounded by ice-water.Six ounces of cream are removed by careful skimming,such a cream containing about 16 per

cent.of fat.To make the infant's food,take of cream 4 ounces,fresh milk 2 ounces, lime-water 1 ounce,and milk-sugar 1 ounce,and boiling water 16 ounces = 24 ounces."

Peptonised Milk.

I have not infrequently seen beneficial results follow the oredigestion of milk in rachitic and other cases characterised by weak gastric or intesinal digestion and assmilation of only a very low percentage of proteids.In this way also higher percentages of proteids can be administered than in possible with simple dilutions.I prefer to use peptogenic milk-powder to this end. Since this consists largely of milk-sugar,the bulk of the powder must be deducted from the quantity of milk-sugar added to bring the mixture to the desired percentage.I have never noticed the alleged unfavourable effects of a partially peptonised diet,even when continued for considerable periods at a time.It will be generally found advisable to discontinue partial digestion by degrees, first gradually reducing the time of action to three or four minutes,and then decreasing the quantity of powder to a third or fourth of the amount originally used,after which it may be abandoned.Milk and cream may be mixed in any desired prpportion and the process of peptonisation can be carried out for from ten minutes to half an hour or longer.It requires about two hours to completely peptonise milk.The use of predisgested milk has the disadvantages that it does not supply the necessary stimulus to the child's stomach,since it is offered already prepared for intestinal digestion and absorption;but where the milk is only partially peptonised,this objection has less weight.It is advisable to commence with half an hours peptonisation,gradually reducing the time as the digestive functions of the child return to normal.There are a number of peptonised preparations described in invalid cookery and nursing books.

Sterilised and Pasteurised Milk.

Medical men in this country were amongst the first to recognise the importance of sterilisation and the necessity for its employment,under certain conditions and at certain times of the year,to render milk fit for the use of children.They were equally prompt to note the advantages of pasteurisation,which also soon came into considerable vogue.Milk and its preparations are sterilised with the idea of guarding against the danger of infection,and the question will be governed by the condition in which the milk reaches the household.It will be unnecessary to have recourse to either sterilisation or pasteurisation,at least during the cold months of the year,if pure milk can be obtained which can be kept cold before and after delivery,and if there is no danger of its contamination during the process of making the infant's food.But it is absolutely necessary to apply heat in some form or other when contamination of the milk has already occurred or is likely to occur during the handling it undergoes on the part of the mother or nurse.Authorities are notyet agreed as to the degree of heat necessary to destroy the bacteria present in milk. Heating from 140. to 155.F.for thirty minutes,the milk being kept in closed bottles to prevent the formation of a pellicle on the surface, will destroy or render harmless the tubercle bacilli and the common pathogenic germs,such as those of diphtheria and scarlatina.It will also kill the majority of the lactic-acid-producing

microorganisms. This temperature will not destroy the spore-bearing butyric and peptonising bacteria and other varieties whic,under certain conditions,may produce that acid.Temperature above 158.F.will destroy the unorganised ferments,and the milk will commence to undergo certain chemical and physical alterations which probably render it easily digested and absorbed.It should not be forgotten that at a low tmperature the pellicle which forms on the milk heated in uncovered vessels will protect the germs it encloses in its meshes and prevent their destruction.Heat should therefore always be applied to the milk in closed vessels,or it should be continually shaken during the time it is being heated.Twenty minutes to half an hour at a temperature of 167.F.will be sufficient to destroy all the lactic-acid-producing germs;but the milk should be heated to 212.F.for at least half an hour in the case of polluted milk.If it be impossible to preserve the milk at a low temperature,more especially during the hot summer months when bacteria multiply so very rapidly,it will be safer to repeat the process of heating every six hours.Whatever disadvantages this degree of heat may entail are more than compensated for by the advantage of destroying all the germs with which the milk is infected.Such milk,even after sterilisation, should not be used for the infant's food unless milk of a better quality cannot be obtained;for it is known that the spores of the peptonising germs are not destroyed even by temperatures as high as 230.F.;and,should conditions favourable for their development be present,the peptonising microorganisms may continue to increase and multiply in apparently sterile milk and considerably endanger the life of the child.Sterilised milk is more digestible than the unboiled liquid and its taste is altered.The disadvantages of sterilisation are in a measure overcome by pasteurisation.Freeman was one of the first to advocate the use of the method and devised an apparatus for the preparation of milk in this way.It consists of"two parts,a pail for the water and a receptacle for the bottles of milk.The pail is a simple pail with a cover;there is a groove extending round the pail to indicate the level to which it is to be filled with water,and supports inside for the receptaclefor the bottles ofmilk to rest upon.The receptacle for the bottles of milk consists of a series of hollow zince cylinders fastened together;this fits into the pail,so that the lower inch of the cylinders is immersed in the water. This receptacle has two sets of horizontal supports,the upper set continues around the receptacle,for use while the milk is being heated;the lower interrupted set is used for raising the receptacle during cooling.Such receptacles are made for ten 6-ounce bottles,seven 8-ounce bottles,three 1-pint,and one ½-pint bottles,and two 1-quart bottles.There is also a large apparatus for the use of hospitals or public institutions which has a receptacle for forty-three 6-ounce or 8 ounce bottles.The apparatus is used in the following way:The pail is filled to the level of the groove with water,covered and put on the stove,the receptacle for the bottles being left out.The bottles of milk are then filled,stoppered with cotton,and dropped into their places in the cylinders.Sufficient water is poured into each cylinder to surround the body of the bottle.As soon as the water in the pail boils thoroughly it is taken from the stove and set on a mat or table or other non-conductor in a place

where there is not a draught of wind blowing on it.The lid of the pail is removed and the receptacle rests on the upper continuous supports.The lid is then rapidly put on the pail,and the pail is this allowed to stand for three-quarters of an hour.During the first fifteen minutes the temperature of the milk rises to about its maximum,or above 65.C.,the point desired for pasteurising,and remains there the remaining thirty minutes.During the last fifteen minutes the cover of the pail is removed,the receptacle is lifted and given a turn so as to rest on the upper supports,this bringing the topof the cylinders containing the bottles above the level of the pail.The pail is then put under a cold-water faucet and the water is allowed to run into the pail and overflow,but it should not run into the cylinders.Thus the hot water is replaced by cold water,and in fifteen minutes the milk in the bottles is of about the temperature of the cold water used.The bottles may then be put into a refrigerator until required for feeding.This rapid cooling is a most important part of a low temperature sterilisation,the importance of which is apt to be overlooked."According to Holt,pasteurisation is the means by which the temperature is raised to,and maintained at, 167.F.for twenty minutes.This kills the bacilli of cholera,typhoid,diphtheria and tuberculosis,the bacillus coli communis and ordinary pathogenic bacteria;but it does not destroy the spores,and milk so prepared will keep for two or three days at room temperature;it does not alter the taste and there is no change in the character and digestibility of the curd.He thinks also that pasteurisation is sufficient for ordinary purposes,but that sterilisation is urgently demanded in cities during hot weather where ice is scarce and milk is liable to serious contamination.He adds that it is important to bear im mind that sterilised milk requires the same modific tion for infant feeding as plain milk.One is not infrequently asked if all milk should be sterilised before using.The milk usually sold in large cities is, as a rule,transported from considerable distances,and is often not consumed for from twenty-four to forty-eight hours;it is thus,especially in hot weather,apt to be contaminated with bacteria.Boiling is the only safe method of destroying the latter.Cautley(loc.cit.)says that pasteurisation from 158. to 167.F.for thirty minutes,followed by rapid cooling in clean,well-stoppered bottles,is sufficient for all practical purposes;such a milk should not be kept longer than from twelve to twenty-four hours;it is not seriously changed in composition or taste and is allowable in most cases.Freeman (Arch.Ped.,Vol.xv)tells us that pasteurised milk was for a period of three years distributed to the poor of New York during the summer.Routine dilutions were used;in some,milk and water in equal parts plus lactose and lime-water,in others,milk and barley-water in equal parts plus cane-sugar.During the three years of its use the number of deaths from diarrhoeal diseases was less by eight hundred and sixty than in the three preceding years,the bottle-distribution exceeding one million.Siegert has made extensive frials with pasteurised milk,at 150.F.for a quarter of an hour,and found the was enabled to supply a germ-free liquid.Leeds(Amer. Jour.Med.Sci.,1895,S.110)recognises thegermicidal efficacy of the method and advises its adoption immediately after milking,the advantages thereof being that

germ-development and toxin-production are prevented. Monti thinks that the milk should be heated to 140.F.for ten minutes and then cooled to 42.8. or 46.4.F.until used,most of the microbes and their spores being placed out of action without change in the composition of the milk.Ravenal(Jour.Vompar.Med.& Vet.Arch.,April,1898)refers to a tabulation of the thermal death-point of some of the most important germs:

Germ.	Temperature.	Exposure.
Bacillus diphtheriae....	58. C.(136.F.)	for ten minutes
Typhoid bacillus.....	56.C.(133.F.)	" " "
Pneumococcus.....	52.C.(125.F.)	" " "
Bacillus coli communis..	60.C.(140.F.)	" " "
Bacillus acidi lactis...	56.C.(133.F.)	" " "
Staphylococcus pyggenes aureus.....	58.C.(136.F.)	" " "
Staphylococcus pyogenes albus.....	62.C.(144.F.)	" " "

Bang(Brit.Congr.Tubercul.,1901)says that fifteen minutes at 140.F.will rid milk of tubercle bacilli danger and allow of their injection into the peritoneal cavity without dangerous results;this temperature so weakened these germs that after pasteurisation for two minutes they could not cause alimentary infection.In some of his experiments higher temperatures were used - 158.F., 167.F.,and 176.F. - with the milk from tuberculous udders,but sometimes failed to kill the tubercle germs;but as the milk was heated in open bottles,this failure was ascribed to the uneven application of the heat to the pellicle and the foam on the surface of the liquid.Smith (Phila.Med.Jour.,Oct.,1901)also blamed the pellicle of the milk for the failure in some of his experiments. Wroblewsky states that certain of the calcium salts which are normally soluble are made to enter into insoluble combinations by high temperatures;while Duclaux points out that the gastric ferments are effective only in the presence of minute quantities of calcium and other mineral salts,the mineral varying with the specific form of fermentation.If the calcium salts are rendered insoluble by heat,then the coagulation of casein will to that extent be arrested or delayed.In support of this idea may be adduced the fact that boiled milk undergoes coagulation by rennet only with great difficulty.Since this coagulation in the stomach seems to be necessary for the comfortable digestion of milk and its absorption into the system,it is certainly questionable whether,as a rule,boiled milk can be absorbed and assimilated as readily as milk which has not been brought to a temperature sufficient to change the condition of the calcium salts.On the other hand,this action may sometimes be of decided advantage in those conditions of the child's stomach in which the action of rennet,either directly or reinforced by the presence of fermenting bacteria,is so great as to give rise to firm curdling.Blackader holds that unheated milk most likely contains ferment-like bodies which,when absorbed,are of great value to the system.Babcock and Russell found that milk obtained in a perfect sterilty undergoes self-digestion owing to the presence of a trypsin which is readily destroyed by heat.Temperatures of over 176.F.would seem to cause a lasting chemical and physical alteration in the milk. Troitsky(Arch.f.Kinderh.,1896,Bd.19)is quite convinced that ordinary lactic acid ferments and pathogenic

microorganisms of milk,including the tubercle germ,are killed by a temperature of 176.F.for ten minutes or 155.F. for half an hour.The casein ferments resist heat much better.The bacillus subtilis,tyrothrix tenuis,and bacillus mesentericus vulgatus produce spores which are only destroyed at very high temperatures.He adds that if the adult microbe dies at about 212.F.,its spores can for sixty seconds resist 239.F.Jacobi(loc.cit.)holds that for pasteurisation the milk should be heated to from 150. to 155.F. for twenty minutes,but that it would be wise to continue heating for a longer period.Johannessen(Address at the Paris Congress,1900)is of the opinion that,if the cows are properly fed and other precautions observed,it will be possible to obtain a primarily germ-free milk;but as things are at present,the milk must be pasteurised and then kept cool and given to the child within twelve hours;he does not think there is any risk of altering the chemical composition of the milk to any appreciable extent by heating it to 158.F., at which point disease-producing germs are destroyed. Getty(Arch.Ped.,Vol.xiv)reduced the total mortality of his observations during a period of two years,and reduced the gastrointestinal fatalities fifty per cent.,by using milk pasteurised at 167.F.for twenty minutes,it being separately bottled,plugged with sterile cottonwool and cooled and preserved on ice.Heuppe believes in the application of heat below 166.F.,as above that point the milk is chemically changed.Campbell(Brit.Med.Jour., Sept.12,1896)prefers pasteurisation to sterilisation,as the former has fewer disadvantages;and Smith(Treatise on the Medical and Surgical Diseases of Infancy and Childhood,1896)is in accord with this view.Campbell(Mont. Med.Jour.,1900,No.29)describes a cheap way of pasteurising milk at home,the necessary appliances being a jar, the cork of which is perforated for a chemical thermometer,and sterile non-absorbent cottonwool.The jar is filled with the milk to be pasteurised,the cork,with the thermometer in place,inserted,and the whole placed in a saucepan of water and heated until the temperature of the liquid reaches 160.F.;the pan is then set at the back of the stove for twenty minutes.The cork is next replaced by a cottonwool plug,and the milk can now be used for kept cool for future requirements.Douglass(Glasg. Med.Jour.,1900,liii)thinks that the unpleasant taste of boiled milk is in large part due to the film which forms on the sides of the vessel above the bubbling liquid.As the fluid subsides,this film becomes overheated and charred and is carried back into the milk at its next ebullition,in proof of which idea he points to the fact that if the milk is boiled in a flask and constantly agitated,the alteration in taste is much reduced.He is strangly infavour of pasteurisation as there is some vital property of fresh milk which a temperature of 212.F.destroys.Marfan(Treatise on Alimentation,1899) does not care for pasteurisation,as it requires complicated appliances and the milk must be rapidly cooled at once;further,it keeps good only for a short time,and it is impossible to be certain that all the lactic ferments are destroyed.Comby(Treatise on Diseases of Infancy,1892)is doubtful about its destroying all the pathogenic germs,though the milk is undoubtedly preserved. Bierdert(Kinder.im Säuglings.Ed.4,Stuttg.,1900)thinks that the method should be reserved for institutions with comparative freedom from contamination of the

milk,and holds that,though all the lactic acid bacilli are destroyed by the method,the proteus and coli groups are not.Koplik(Arch.Ped.Vol.xv)finds that the method kills most disease-inciting microorganisms,but not the milk microbes which are most often the cause of trouble, viz.,those which form lactic acid,those which form butyric acid,and the peptonising bacteria.The lactic acid and butyric acid groups are not affected by any temperature at or below 212.F.,although cold inhibits their growth;heating to from 90. to 92.C.destroys the lactic acid group.Since the butyric and the peptonising groups are not destroyed by pasteurisation,he regards milk so prepared as uncertain and at times a dangerous food for children and others,milk infection having occurred in some of his patients fed thereon.He therefore advises sterilisation for ten minutes at either 90. or 100. C. Miquel,in the course of careful experiments,found that all pathogenic microorganisms were destroyed at the end of an hour by heating to 105.C.,at the end of thirty minutes by a temperature of 107. or 108. C.and also at the end of fifteen minutes bya temperature of 110.C. Troitsky holds that sterilisation is complete only after exposure to 100.C.for one and a half to two hours,or even lomger.Complete sterilisation of milk,therefore,can only be effected by heating it to 100.C.for one and a half to two hours,to 105.C.for one hour,to 107. or 108. C.for thirty minutes,or to 110.C.for fifteen minutes. Higher degress of temperature,daily sterilisation at 100.F.for half an hour during three days,the so-called fractional sterilisation or Tyndallisation,or heating in a the special apparatus known as the autoclave,where the pressure can also be raised,would all serve the same purpose,but these methods are not used just now.The method of boiling or sterilising milk in single portions for the use of infants was first advocated by Soxhlet.Ma-rfan thinks that milk heated in a double boiler,such as the Soxhlet apparatus,to 212.F.for forty minutes will remain sterile for four tofive days if the conditions are favourable.If this is used within twenty-four hours, it may be considered perfectly sterile.The same physical and chemical changes are found in this milk which are present inany milk heated to or above 80.C.If rubber corks are used,as in the apparatus above referred to,a disagreeable odour or taste amy beimparted to the contents of the bottle.The actual temperature of the milk in the bottles of the Soxhlet apparatus never exceeds from 95. to 96.C.,so that the casein ferments cannot be destroyed;the slow development of the latter is due to the tight closure of the containers with consequent exclusion of all oxygen.It seems likely that sterilised milk is easier of digestion than the raw liquid;but the only satisfactory test would be to feed a series of infants of equal ages and weight on both kinds of milk, the amounts consumed being carefully noted;in short,to perform metabolism experiments.Test-tube observations are not reliable.With properly sterilised milk accidents of infant feeding are greatly reduced in number,increase in weight is much more steady,and there is a diminution in the incidence of all forms of gastrointestinal derangements.It has been shown that pure cow's milk,if sterilised,can be digested by the infant as soon as it is born.It is said that the avoidance of excessively high temperatures,the exclusion of air,and rapid after-

cooling have served to diminish the changes brought about by sterilisation,which are found only to a slight degree,in the ordinary commercial sterilised milk.It is important that this milk should be used within a week, otherwise the fat droplets will separate.Heating to 40. C.and a thorough shaking will restore the emulsion,and such agitation also tends to preserve the percentage of phosphoric acid.If the bottle is not shaken,a layer of mucus is formed on the sides and the bottom,containing from a half to a thirtieth of the total phosphoric acid present.Such facts as these,however,are not serious objections to the use of sterilised milk.Biedert(loc.cit.) is much in favour of the method of sterilisation and affirms that the objection urged against it,viz.,the destruction of the lactic acid bacteria,does not obtain, because many of these germs are already present in the mouth and stomach of the infant.He recommends that the milk mixture should be put up in separate bottles,sterilised,immediately cooled,and kept cool until required for the food;simple boiling in a covered vessel,provided the milk is not afterwards disturbed,will do in the case of families who are unable or unwilling to carry out this process.Shaking the bottles in a circular direction before use will prevent the separation of the fat in large globules after sterilisation.Fenwick(The Disorders of Digestion in Infancy and Childhood,1897)prefers pasteurisation to sterilisation except in cases of milk contamination,actual or suspected.Thomson(Man.Dis.Childr., 1898)does not consider pasteurisation as quite satisfactory and advises sterilisation in the case of those living in towns and cities,whilst the milk is fresh.Comby (loc.cit.)urges sterilisation under the same possibly infective circumstances;he allows his patients to have raw milk only in exceptional cases,as in the country dis-tricts or where the cows react negatively to tuberculin.Variot(Jour.de Clin.et Thérap.Inf.,viii,1897)considers it advisable to have the milk sterilised in bulk at 115. C.at the dairy farms immediately after milking,it being then hermetically sealed in convenient-sized bottles with proper directions as to use.He usually gives whole milk after one month;to those with weak digestion he gives it after the second or third month;before that time he advises it diluted with from a third to a fourth its amount of water.Most of his patients did well;though some developed constipation and anaemia,scurvy was never observed and rickets only rarely.Baginsky(Lehr.der Kinderkr., 1899)considers that the Soxhlet method gives the best practical results,although it does not completely sterilise the milk;immediate cooling and use within two days are essential factors,however;he has never seen scurvy follow its ingestion.Troitsky(loc.cit.)thinks that it is likely that sterilisation produces some changes in milk,but does not render it indigestible;both sterilised and raw milk are good culture media,but microbes grow less readily in the former;the bottle of sterilised milk may be opened once or twice without becoming infected,but each repetition increases the danger of germ-invasion.Koplik(loc.cit.)has give n long and careful consideration to this question and does not consider sterilised milk more difficult of digrstion than the raw liquid.Starr regards sterilised milk as especially useful on a long journey during the heated term and as a temporary change of diet for delicate children suffering

affections of the digestive tract.Ashby and Wright(Dis. of Childr.,1900)hold that the home sterilisation of milk is impossible;that,if the milk is fresh and clean,a temperature of from70. to 75.C.is sufficient,half an hour at 100.C. being otherwise required.Gernsheim (Jahr. f.Kinderh.,Vol.xlv)states that it is possible to obviate variations in the fat content of the separate bottles only by thorough stirring and shaking of the milk before filling;if the milk is kept in a large container,it must be stirred in a circular direction before being poured out;sterilisation of the vessels will avoid germ infection.Numerous objections have been urged against sterilisation of milk.This Carstens is against theadministration of such milk exclusively beyond the ninth or tenth month,and adds that a dilution of one to three is necessary only for small infants during the first month, stronger concentrations being advisable after the second month.Starck(Verhandl.der Gesells.Deut.Natur.u.Aerzte, 1898)is of the opinion that the prolonged and exclusive use of sterilised milk for infants very often gives rise to nutritional disturbances,such as severe anaemia,rickets,scurvy,etc.;the uniformity of diet is largely responsible for this,besides the physical and chemical changes produced by sterilisation;if clean raw milk cannot be obtained,the milk should be heated,to what degree and for how long depending on the circumstances of the individual case;in certain conditions sterilisation is necessary;fresh,clean,boiled milk is the normal substitute for maternal milk,and gives as good results as sterilised milk without its drawbacks.Constipations, scurvy,etc.,have been not infrequently excited by the use of sterilised milk.Monti(loc.cit.)is certain that sterilised milk is inferior to the ordinary liquid,rickets,anaemia,and indigestion being often occasioned.Barton (Brit.Med.Jour.,Jan.,1897)holds that,in the absence of simultaneous fresh food,completely sterilised milk will give rise to scurvy.Campbell(loc.cit.)has seen the same affection and rickets arise from the same cause,and states that,as it is not well digested,the infant receives an insufficiency of food,especially of carbohydrate and fat.The Collective Investigation of the American Pediatric Society on Infantile Scurvy in North America (Arch.Ped.,Vol.xiv)included three hundred and fifty-six cases of scurvy,sterilised milk being the only food in sixty-eight of them.Jacobi(loc.cit.)points out that, unless there is perfect sterilisation of the milk,the resistant spores of microbes may find a better opportunity for development,since the lactic acid ferments have been destroyed.The longer such milk is kept before it reaches the consumer the more dangerous it becomes.Renk found that separation of cream from sterilised milk occurs to a slight extent within one week of sterilisation,and that later forty-three and a half per cent.of the cream undergoes separation.Jacobi thinks that the question of chemical changes not yet settled and that the substitution of sterilised milk for the maternal secretion as the sole food for the infant is wrong,gastrointestinal troubles,rickets and scurvy being sometimes induced.The physical and chemical changes which are said to occur during the process of milk sterilisation may be summarised as follows:(1)Lecithin and nuclein decomposition, according to Baginsky,Starck,Bierdert,Jacobi,and Edlefsen;also of nucleon,according to the last mentioned author also.(2)Increase of inorganic phosphorus and

diminution of organic phosphorus, according to Baginsky. (3)According to Monti, Dawson Williams, and Campbell, the greater part of the phosphates are rendered insoluble. (4)According to Ashby and Wright, Jacobi, Dawson Williams, and Campbeel, there is precipitation of the salts of calcium and magnesium. (5)According to Johannessen, Dawson Williams, and Campbell, the greater part of the carbon dioxide is driven off. (6)According to Biedert, normal lactic acid fermentation is prevented. (7)According to Leeds and Baginsky, there is complete destruction of lactose, though Duclaux denies this and Johannessen says that it is not seen below 110.C. (8)According to Holt, Renk, Monti, Jacobi, and Carpenter, there is caramelisation of certain portions of the lactose. (9)According to Renk, Biedert, Monti, Ashby and Wright, Jacobi, Smith, Campbell, and Johannessen, the fat emulsion is partially destroyed or rendered imperfect by the coalescence of the fat globules. (10)According to Renk, Koplik, Cautley, Jacobi, Freeman, Smith, and Campbell, separation of the serum albumin commences at 75.C. and increases as the temperature is raised. (11)According to Baginsky, Leeds, Holt, Koplik, Smith, and Campbell, rennet renders casein indigestible. (12)According to Leeds, Holt, Jacobi, and Campbell, casein is slowly and imperfectly acted upon by pepsin and pancreatin, Leeds also affirming that the proteid substances become attached to the fat globules and probably to some extent interfere with the assimilation of fat. (13)According to Starck, peptones can be found after prolonged sterilisation, they being produced by the action of chlorides on casein. (14)According to Leeds and Smith, the starch-liquefying ferment is destroyed and coagulated. Renk, Holt, Cautley, and Campbell affirm that the taste becomes unpleasant; but, as the infant has not much faculty of taste, this is, says Marfan, not of much importance. Milk boils at 101.C., according to Marfan; it rises before boiling, commencing at 75.C., according to Comby, and 85. C., according to Gautrelet. It is necessary to break up the skim on the surface of the milk and to keep it on the fire until large bubbles appear. Milk boiled from three to four minutes does not contain lactic ferments or pathogenic microorganisms; but it will not keep for any length of time, because the spores of the casein ferments are not destroyed. The skim is composed of casein; but, since the latter is present to excess in Cow's milk, Marfan does not see any objection in this, and he thinks also that the increase in density to which Duclaux and Crolas called attention is too insignificant to be of any consequence. The milk, he adds, if it can be boiled directly after milking and used the same day, is quite safe. Jacobi(loc.cit.)states that pasteurisation and sterilisation are logical developments of his plan of boiling milk which he advocated forty years ago. He affirms that boiling forces out the air and that there is destruction of such germs as the bacilli of typhoid, diphtheria, tuberculosis, cholera, and the oïdium lactis; some varieties of proteus and most of the coli communis are rendered harmelsss, and the hay bacillus and the bacillus butyricus are not killed. He thinks that the daily home sterilisation of milk is far preferable to the risky purchase from the dairies. Flügge recommends that the milk be boiled for a short time to destroy the majority of the disease-producing germs, then cooled rapidly to protect it from infection by the air, cooling

hindering or checking the development of such dangerous forms as the peptonising and anaerobic microorganisms. He considers Soxhlet's method requires too long boiling and does not lay sufficient emphasis on rapid cooling, and adds that physical and chemical changes occur from prolonged heating.Czerny(Jahr.f.Kinderh.,Bd.49)considers ten minutes' boiling sufficient,whereas Henoch(Vorles. ueber Kinderkr.,1897)prefers three times as long,and holds that pure milk only should be used.Bendix(Lehr.der Kinderkr.,1899)never exceeds half an hour,lest alterations in taste or other undesirable changes may be produced;he thinks that such milk should never be kept longer than twenty-four or thirty-six hours prior to consumption.Schlossmann in boiling of milk sees the important objection of analteration in the phosphorus compounds,the albumins and the fats.Holt(loc.cit)says that the changesin milk from the application of heat commence at 180.F.and become more marked the higher the temperature and the longer it is maintained;sterilisation should be done at the dairy;its value consists in the prevention,not the cure,of disease;if pure milk can be procured fresh,it is not required.Richmond says that the the distinguishing point between sterilised and new milk is the state of the albumin.In milk which has been heated,coagulation does not occur;but if it is acidified or saturated with magnesium sulphate,the albumin separates with the casein.It seems to be changed from a soluble to a colloid form.Not more than 0.1 per cent.of albumin is found in sterilised milk in a soluble form.In sterilised milk there is a very slow separation of the cream,in six hours only a tenth of the amount being present that should be found in fresh milk.In twenty-four hours the bulk of the cream will rise,but the entire amount will be less thanthat fromthe same amount of raw milk,while the fat percentage will be forty as against thirty in new cream.Water is the only constituent which is affected by partial freezing.Veith found that exposure of large quantities of milk to -10.C.for three hours caused it to freeze,except in the centre.The ice consisted of two layers,one of cream and the other of skimmed milk. The cream contained 19.23 per cent.fat,2.65 per cent. proteids,3.33 per cent.lactose,and 0.52 per cent.ash. The milk contained 0.68 per cent.fat,2.80 per cent.proteids,3.95 per cent.lactose,and 0.60 per cent.ash.The liquid portion contained 5.17 per cent.fat,5.38 per cent. proteids,7.77 per cent.lactose,and 1.18 per cent.ash. These results show that milk cannot be frozen in blocks, from which pieces can be cut off and melted for use, withouta very serious alteration ih its composition. A change takes place in the albumin at 70.C.;it is not precipitated,but is changed into a form which is precipitated by acid magnesium sulphate and other precipitants of casein.Heating above this point alters the taste and smell of the milk.At about 80.C.there is a change in some of the organised principles,and when the temperature nears boiling point there is a deposition of calcium citrate.By keeping it at this temperature for some time, slight oxidation sets in with the production of slight traces of formic acid and marked reduction of the rotary power of lactose,a brown colour being simultaneously produced.A deposition of salt and perhaps of albumin also occurs in the globules of fat,which occasions their mean density,causing them to rise slowly to the surface when the milk is subsequently cooled.During the heating

the fat globules are expanding and may sometimes coalesce.Richmond thinks that the degree of affection of the digestibility of heated milk is uncertain;milk which has been heated is curdled less readily by rennet than fresh milk,but this would seem to be due to the deposition of calcium salts and not to casein change;the assertion that sterilised or boiled milk is digested more easily than fresh milk is explained by the fact that it has a softer curd and does not curd so readily in the stomach of the child.Some interesting experiments were carried out by Michel(L'Obstétrique,Vol.i,1896; La France Méd.,1898,p. 402)upon the artificial digestion of raw and sterilised milk with hydrochloric acid and pepsin,with pancreatin in neutral and alkaline solution,digestion of the curd produced by the laction of the lab-ferment with pepsin and hydrochloric acid,digestion of the curd so produced by pancreatin,and complex digestive processes with lab, hydrochloric acid,pepsin and pancreatin.The amount of the peptones was estimated by the polarimeter,the basis employed being the ratio of the peptones to the total nitrogen,one gramme of the latter representing 6.41 grammes approximately.The temperature employed was 40.C. and the digestion at this heat was effected in the incubator.Raw milk furnished 18.75 grammes of peptones;ster-ilised at 115.C.,17.53 grammes,the former showed rather more rapid digestion.Digestion for five hours gave 21.76 grammes for raw milk and 24.64 grammes when the milk was sterilised at 115.C.Digestion in the incubator for three and a half hours at 40.C.gave 7.57 grammes for raw milk and 10.72 grammes for the sterilised liquid.When the digestion was continued for eight and a half hours, raw milk gave 14.316 and sterilised milk 12 grammes of peptones.The curd was digested much more quickly by pancreatin when sterilised milk was used,- 28.22 grammes,- than when raw milk was employed - 13.12 grammes.The digestion of raw milk by lab-ferment,pepsin and hydrochloric acid was slower in the first three hours than that of sterilised milk,- 9.59 grammes as against 11.32 grammes,- at the end of six and nine hours it was more rapid,giving at the latter period 16.64 grammes as against 14.91 grammes.Further digestion with artificial pancreatic juice for six hours gave 21.76 grammes of peptones for raw milk and 24.57 grammes for the sterilised liquid.Michel remarks that sterilised milk contains almost no coagulated albumin;but that in contact with the acid gastric juice the albumin of sterilised milk precipitates,while that of raw milk remains in solution;this albumin,whether in solution or not,is of long and difficult peptic digestion;and he adds that the result of these experiments shows that sterilisation does not injure,but rather increases,the digestibility of the milk albuminoids.This point is,however,very doubtful.

Condensed Milk.

Condensed milk,like other patented foods,contains too much sugar and too little fat to give it any value whatever except on occasions;and while it does make fat infants,these children,like those fed exclusively on the advertised infant foods,have no real stamina and are liable to break down in childhood at the first attack of any serious ailment.One not infrequently finds that mothers will point with pride to healthy grown children,and state that they have been brought up on condensed milk or this or that or the other food;but

the fact remains that if they had been attacked by any serious disease of infancy they would probably have died,when children fed on modified cow's milk might have come through the affection without difficulty.The explanation is that these infants were fortunate enough to escape any severe disease until they had been on a general diet long enough to enable them to resit it.That the infants reared in this way are fat is merely because sugar makes fat,and these foods and condensed milk are mainly composed of sugar,which is necessary as a preservative just as it is in the case of jam.We may take it, then,that the success with which some infants are reared on a diet of condensed milk,or even of cow's milk simply diluted with water,would seem to indicate that certain children thrive,for a time at least,on low fat percentages,though such cases must be comparatively rare.These children not infrequently show signs of rickets,anaemia, scurvy,obesity,and other nutritional anomalies.The rapidly growing organism needs a plentiful supply of fuel, which is furnished in the hydrocarbons and carbohydrates,while the larger part of the nitrogen serves to build up the rapidly growing muscular system.The starches and fats thus diminish the consumption of nitrogen, and the term nitrogen savers has not inappropriately been applied to them.Condensed milks are enormously popular amongst the public,and it would appear that millions of tins are each year sold by the various firms. The poorer people are,indeed,obliged to use it,owing to their difficulty of obtaining or paying for the genuine article;even in the most remote country places it is in wide vogue,as practically all the milk is sent to the towns by the farmers under contract.It must be well diluted before it is given to the child;and in this diluted condition it has the advantage that the casein does not clot in such heavy curds as that of raw milk;further the milk fresh from the tin is sterile.It is handy, as when travelling,as a temporary substitute for fresh milk or in places where the latter cannot conveniently be obtained.It is also sometimes of service temporarily in cases of acute diarrhoea,vomiting,and other gastro-intestinal disturbances;in these cases the dilution renders its easier of assimilation,and by gradually adding to it a little cream and ordinary milk the infant's stomach can not infrequently be trained,as it were,to tolerate cow's milk modified according to indications. By the addition of eight to twelve times its amount of water,the proteid and fat are reduced to a per cent.and less,while the proportion of sugar becomes from five to six per cent.This amount of sugar will do,but the proportion of proteids and fat(especially the latter)is too low.It has been suggested as a possible explanation of the infants doing well on condensed milk that a so-called teaspoonful is really about twice that quantity, as almost as much of the thick syrupy milk sticks to the bottom and edges of the spoon as the latter holds. The child is,therefore,in reality given an excess of sugar,a proper proportion of proteids,and a deficiency of fat;the sugar can be converted into fat and make the infant plump and heavier;the proteids are presented in an easily digestible form,as they clot in much finer curds than raw cow's milk;while the fat,being in fine emulsion,is also readily assimilable,as a rule.But,in conjunction with many other observers,I have noticed that a prolonged exclusive diet of condensed milk sooner

or later gives rise to rickets or other nutritional disturbances as already mentioned, and that the child, while to the mother's eye plump and healthy, is a weakling and liable to succomb to any intercurrent disease - the same being due to the deficiency in fat, the excess of carbohydrates and the lack of freshness of such milk. I do not, however, entirely condemn condensed milk in infant feeding, for it has its uses, like most other things, as in cases in which persistent, intelligent modifications of cow's milk have failed, and where lack of resources or of intelligent co-operation on the part of the mother prevents the adoption of more elaborate methods of feeding. As a temporary measure, I have given condensed milk for short periods to tide over emergencies, especially amongst the poor during the hot months of the year, when it is difficult to secure good milk and to obviate its contamination. In such cases as I have employed it, I have usually tried to make up for its drawbacks by the addition of fresh cream, so that the child will secure therefrom enough nourishment to meet all its requirements, even for some time, though I always endeavour to place the infant on cow's milk as soon as possible. Condensed milk is made by heating cow's milk under pressure for an hour or so, in order that the germs may be destroyed and the casein rendered small and more digestible; it is evaporated in a vacuum until it becomes thickened and jelly-like, sugar being added as a preservative. It is important to select only those brands which contain high fat percentages, - some as high as twelve per cent., - and to use only those which are preserved by the addition of cane-sugar - the milk being administered in the proportions of condensed milk one ounce, cream one ounce, water nine ounces, and lactose three drachms. Analyses have shown that there are two main varieties of condensed milk, viz., those containing comparatively little sugar and those to which cane-sugar has been added; the first form contains from fifteen to eighteen per cent. of milk-sugar, the latter from fifteen to eighteen per cent. of milk-sugar and from thirty-six to forty per cent. of cane-sugar. The composition of condensed milk varies considerably according to the particular brand. The unsweetened kind, though theoretically preferable, has the disadvantage of not keeping for more than a very short time after the tin is opened. The milk should be diluted with water at least equal in amount to that which has been evaporated, i.e., usually twice its volume; and in the case of a child of ten months a dilution of ten times might be employed. The following table, by Leeds (loc. cit.) gives the composition of condensed milk diluted one in eight by weight:

	Sweetened Condensed Milk.	Diluted 1 - 8 by Weight.
Fat.....	12.10	1.51
Lactose.....	16.62	2.06
Cane-sugar.....	22.26	2.78
Proteids.....	16.07	2.01
Ash.....	2.61	.32
Total Solids..	69.66	8.68

The same author tabulates the composition of fifteen varieties of condensed milk, showing the minimum, maximum and average proportions of the various constituents:

	Minimum.	Maximum.	Average.
Proteids	7.87	10.91	8.82
Fat	7.64	12.13	8.67
Lactose	10.00	16.98	11.66
Cane-sugar	36.09	42.65	40.39
Ash	1.82	2.15	1.83
Milk solids	28.37	36.92	31.71
Fat in original milk	3.06	4.52	3.69
The average number of times condensed			2.37

He also gives a table of comparison between condensed milks, which brings out the differences between milks con-densed with and without the addition of cane-sugar:

	Milk and cane-sugar. Mean of forty-one analyses.	Milk without added sugar. Anglo-Swiss milk.
Proteids	16.07	11.36
Fat	12.10	13.21
Lactose	16.62	15.29
Cane-sugar	22.26	0.00
Ash	2.61	1.78
Total solids	69.66	41.64
Water	30.34	58.36

The following is a comparative tabulation of conden-sed milk as usually given and prepared from the above samples:

	No.I.sample with 8 times its weight of water(Leeds).	No.II.sample with 5 times its weight of water (Leeds).	Analysis of condensed milk as ordinarily used(Meigs).
Proteids	2.01	2.27	0.868
Fat	1.51	2.64	1.095
Lactose	2.08	3.05	5.206
Cane-sugar	2.78	0.00	
Ash	0.32	0.36	0.158
Total solids	8.70	8.32	7.327
Water	91.30	91.68	92.673

Hutchinson(loc.cit.)has analysed condensed milks to the following effect:

	Proteid.	Fat.	Carbohydrate.
Sweetened	10	13	52 = 15 milk-sugar 37 cane-sugar
Unsweetened	9	11	15 - milk-sugar
Sweetened Milk 1 part, water 7 .	1.2	1.6	6.5
Unsweetened Milk 1 part, water 6 .	1.2	1.5	5.6

The same author finds that condensed milk, diluted one to twenty-four, has the following composition:

Nestlé's Milk.	Per cent.
Fat	13
Proteid	2.0
Sugar	8.17

Ashby's analysis of unsweetened condensed milk is that when it comes from the tin and after a certain degree of dilution:

	Unsweetened condensed milk.	Diluted 1 - 6 by weight.
Fat	9.9	1.65
Lactose	13.3	2.2
Proteids	8.9	1.5
Ash	1.9	.16
Solids	34.0	5.51

By such a dilution, in both the sweetened and the unsweetened varietis of condensed milk, there would be a deficiency of fat; in the former there is an excess of cane-sugar, and in the latter lactose is below the normal amount. It is therefore necessary to add cream to both, and a solution of milk-sugar to the latter. Owing to its great deficiency in cream, separated condensed milk should not be used as a food for infants. Holt (loc.cit.) finds that the Eagle brand of condensed milk is composed of the following ingredients:

	Undiluted.	Diluted with six parts of water.	Diluted with twelve parts of water.
	Per cent.	Per cent.	Per cent.
Fat	6.94	0.99	0.53
Proteids	8.43	1.20	0.65
Sugar	50.69	7.23	3.90
Salts	1.39	0.17	0.10
Water	31.30	90.49	94.82

The same author tabulates the composition of Swiss, Austrian and Norwegian condensed milks as follows:

	With sugar. Per cent.	Without sugar Per cent.
Water and volatile substances	20.0-30	46.5-55
Salts	1.5-3	2.0-3
Fats	8.0-12	13.0-20
Albuminoids	10.0-13	13.5-27
Lactose	10.0-15	12.5-18
Cane-sugar	30.0-45	.....

The percentages obtained by the addition of cream to condensed milk will be seen from the following table, the figures being based on Holt's analysis of the Eagle brand of milk:

	Proteids. %	Fat. %	Sugar. %	Salts. %
I. Cream (12%) one part	3.8	12.00	4.2	0.64
Condensed milk one part	8.4	7.00	50.00	1.39
Water six parts	...	.....	.....	....
8)	12.2	19.00	54.2	2.03

			Per cent.
II. Cream (16%) one part. Condensed milk one part. Water ten parts.	=	Proteids.....	1.5
		Fat.....	3.00
		Sugar	6.75
		Salts.....	0.25
III. Cream (16%) one part. Condensed milk one part. Water ten parts.	=	Proteids.....	1.00
		Fat.....	2.00
		Sugar.....	4.5
		Salts.....	0.16

The proteid percentage can be increased without appreciably increasing the fat by using whey to replace a portion of the water in the diluent, being careful not to allow an excessive increase of the sugar. It is possible to increase the fat by using cream of higher fat

percentage,and the proportion of the proteids can also be increased by using cream of lower fat percentage.It is advisable to be careful about domestic measures in these cases.Thus,Still(Practitioner,1904)considers the ordinary teaspoon very variable in capacity,it seldom holding exactly a drachm and the amount taken from the tin of milk varying according to whether the sppon is dipped into the tin or the milk carefully poured out until level with the edge of the spoon. His experiments showed that an average teaspoon of two-and-a-half-drachm capacity may hold three drachms if carefully dipped into the tin;and that a larger spoon,of three drachms,may hold four drachms - about a drachm less in each case being the usual when the milk is carefully poured into the spoon.Monti(loc.cit.)says that there are two main varieties of condensed milk,the sugar-sweetened and the unsweetened;to prepare the former,cow's milk with more or less sugar added to it is condensed in a vacuum.It then contains all the constituents in an unaltered form of the manufacture has been properly performed.Not infrequently,on opening the tin,we find a skim composed of crystallised sugar and dried milk materials,under which the milk willkeep for a long time;microscopically,there are fat droplets intact and numerous sugar crystals.Fermentation germs are present only when the tin has been opened for some time.The large proportion of sugar tends to give rise to digestive disturbances and requires the milk to be abandoned in infant feeding.He has seen rickets,anaemia,boils,and other troubles arise and holds that it is only suitable for summer use and long journeys for temporary use.He does not believe in the unsweetened form of condensed milk,which is made by heating cow's milk for a short time above the boiling point of water and then evaporating in vacuo at about 140.F.Cautley(loc.cit.)has seen condensed-milk-fed infants become fat,flabby and anaemic,this being due to the excess of sugar in that liquid,and insufficiency of proteids for tissue nutrition.In some of his cases where no other food was given there developed rickets,scurvy,bronchitis or gastrointestinal affections.He uses it only as a temporary food,when cow's milk is not procurable,or to tide over an emergency.He has noticed that it spils soon after the tin is opened,that it is not always germ-free,and that there is a considerable variations in the milk according to the firm preparing it.Ashby and Wright(loc.cit.) never give condensed milk for more than a short period, during which it is sterile and does not curdle easily. They have observed that it is sometimes retained by the child when so-called fresh milk is vomited on occasions gastrointestinal troubles;they prescribe only those brands which contain plenty of fat,some of them having as much as twelve per cent,diluted in the proportion of one to eight or one to ten.They regard it as likely to produce scurvy when too long administered.Starr(loc. cit.)see in condensed a useful agency for temporary use under such conditions as those already named;but admits that it contains too much cane-sugar and too little nutriment for the growing infant.Those fed on it,though fat,are pale,lethargic and flabby;they have little resistance to disease;dentition is not infrequently delayed and rickets sometimes occurs.Fenwick is of the same opinion and points out the wide variations in the percentage of fat in the different makes,some containing little

or none, and recognises in all of them only a temporary utility. Saunders (Med. Rev., June 13, 1896) ascribes the popularity to one or other of three factors. First, bad milk cannot be condensed and, although the pathogenic micro-organisms may not be killed, the sugar acts as a preservative. Second, as a rule, the condensing processes occasion molecular changes in the casein, which are of great service. The curd produced by the action of rennet or acids is intermediate in size between that of mother's milk and cow's milk. Third, the fat globules are kept in perfect emulsion, so that it is impossible to separate them in the centrifuge. Though the fat is greatly deficient in amount, this small amount of fat is more available than that of fresh milk because of its perfect emulsion and from the fact that the curd of condensed milk, in the meshes of which some of the fat is entangled, is more digestible than that of raw milk. He thinks that condensed milk should never be used for any length of time without being fortified by cream or cod-liver oil, and he advocates dairy hygiene, the immediate cooling of fresh milk, and the preservation of the same until it is about to be ingested. Carpenter (Edin. Med. Jour., N.S., 1898, No. 4) holds that the cows of Switzerland are more liable to tuberculosis than others, about eighty-five per cent. being affected; also that virulent tubercle bacilli may be in the tins as it is prepared by vacuum evaporation which does not allow of sterilisation. There are a large number of makes of condensed milk on the market, as was long ago pointed out by such writers as Dyer (Brit. Med. Jour., July 27, 1895), who analysed seventeen of them with the following results as regards the percentage of fats:

Make.	Fat Percentage.
Marguerite Brand	0.42
Tea "	0.48
Gondola "	0.48
Cup "	0.49
Goat "	0.56
Calf "	0.60
Wheatsheaf "	0.62
Swiss Dairy "	0.63
Daily "	0.69
Clipper "	0.73
Shamrock "	0.79
Cross "	0.96
Home "	1.02
Handy "	1.49
Nutrient "	2.36
Cow "	2.84
As You Like It Brand	4.23

All the above are unsuitable for infant feeding, as they are prepared from skimmed or partly skimmed milk, and very deficient in fat as compared with the Milkmaid Brand of Anglo-Swiss condensed milk, which contains 10.92 per cent. of fat. The makers of Nestlé's Condensed Swiss Milk claim that it contains 13.13 per cent of fat; and their Ideal Brand is said to be particularly rich in that important constituent. Another well-known make is the Viking Condensed Milk, which is made from the milk of cows fed in the mountains of Norway, the dairy hygiene being of the most up-to-date kind. The folliwing analyses indicate its composition:

	Chemical and Assay Laboratory.	"Lancet" Laboratory.
Water	66.0	67.59
Total solids	34.0	32.41
Proteids	8.9	.....
Lactose	13.3	.....
Fat	9.9	9.00
Salts	1.9	1.89

In view of the apparent fact that this milk is concentrated to a third of its volume, the raw milk would be made up of 11.33 total solids; 2.97 proteids; 3.30 fat; 4.43 lactose; and 0.63 salts; - from which it will be noticed that as compared with English milk there is a deficiency of both fats and proteids, the same objection being applicable to the milk of Switzerland and other countries.

Humanised Milk.

Humanised milk is the bovine production so modified in composition as to approach maternal milk as closely as possible, the casein being decreased and the fats and sugars increased. Leed's prescription is as follows: "One half-pint of pure cold water, one measure of peptogenic milk powder, one half-pint of fresh cold milk, and four tablespoonfuls of sweet fresh cream. First dissolve the powder in the water by rubbing and stirring with a spoon, then add the milk and cream; mix well; heat in a saucepan, with constant stirring until blood-warm - not too hot to be agreeably borne by the mouth; keep at about this temperature for ten minutes; then bring quickly to boiling-point; pour at once into a clean bottle, shake thoroughly, cork tightly, and place directly on ice or in a cery cold place. When a feeding is required, pour out the portion and warm it to the proper temperature, lukewarm; always shake the bottle thoroughly before and after pouring out a feeding." It can be prepared in the home by letting fresh milk stand for three or four hours to cream, then removeing the latter and dividing the milk into two parts, one of them for conversion into whey; then mix the latter, the cream and the milk together, with the result that there is obtained a milk with all the fat and soluble proteids, but only half the casein of cow's milk. Monti (loc.cit.) advises dilution of milk one-half with whey and the addition of bicarbonate of soda; and he regards the resulting mixture as the nearest possible satisfactory approach to human breast milk. Some of the commercial humanised products are very unsatisfactory, especially when they have to be sent some distance by rail, the agitation of the journey converting all the fat into butter. Milk of this kind is suitable only for temporary use, prolonged administration producing the very thing it is desired to avoid, namely muscular enfeeblement or nutritional troubles.

Laboratory Methods.

These aim at the supply of modified milk to bottle-fed children, the credit of their introduction being due to Rotch, at whose suggestion the Walker-Gordon laboratories are established in various large towns or cities; the milk is standardised and prepared for each infant according to the prescription of the attending physician. They have been productive of an enormous amount of good; for the child's digestive system is accurately catered for and the possibility of improper feeding by the mother or nurse is obviated. Expense is the principal objection urged against them. The milk supplied

is free from germs and may be sterilised, pasteurised or otherwise treated according to requirements. It is put up in special bottles, each one holding enough for a feed, prior to which there is only required warming of the bottle and the attachment of the nipple. In winter it may be had in basket and in summer is special coolers. In the case of very poor people the milk can be supplied in lar-ge jars and divided into the desired number of feeds by the mother or nurse. Blank prescription forms can be obtained at the laboratory for the use of medical men, on which appear such stipulations as amount of fat, milk-sugar, proteids, lime-water or other diluent, temperature, number of feedings and quantity to be given at each, the infant's age and weight and name and address, date and signature. Such prescriptions are dispensed by mixing together the milk, cream, standard saccharine solutions and water in due proportions. The average percentages of proteids, carbohydrates and fat assimilable by a normal child are as hereunder:

Age.	Fat.	Sugar.	Proteids.	Amount at each feed	No. of feedings in 24 hours	Interval by day in hours.
	%	%	%	ozs.		
Premature infants..	1.0	4.0	0.25	¼-¾	12-18	1-1½
First to fourth day	1.0	5.0	0.3	1-1½	6-10	2-4
Fifth to seventh day	1.5	5.0	0.5	1-2	10	2
Second week.....	2.0	6.0	0.6	2-2½	10	2
Third week.....	2.5	6.0	0.8	2-3½	10	2
Fourth to eighth.... week.....	3.0	6.0	1.0	2½-4	9	2½
Third month.....	3.0	6.0	1.25	3-5	8	2½
Fourth month.....	3.5	7.0	1.5	3½-5½	7	3
Fifth month.....	3.5	7.0	1.75	4-6	7	3
Sixth to tenth month.....	4.0	7.0	2.0	5-8	6	3
Eleventh month.....	4.0	5.0	2.5	6-9	5	4
Twelfth month.....	4.0	5.0	3.0	7-9	5	4
Thirteenth month....	4.0	5.0	3.5	7-10	5	4

The Walker-Gordon laboratories have issued a table showing the average infant's requirements as regards food; it forms a useful guide and indicates the percentages used and the amount of modified milk administered to numerous cases of bottle-fed infants:

Weeks of life.	Amount fed in ounces.	Percentages.		
		Fat.	Sugar.	Proteids.
First.....	1¼	2.00	4.5	0.75
Second.....	1¾	2.50	5.5	1.00
Third.....	2	3.00	6.00	1.00
Fourth.....	2¼	3.00	6.00	1.00
Fifth.....	2¾	3.25	6.5	1.00
Sixth.....	3	3.25	6.5	1.25
Seventh.....	3	3.50	6.5	1.25
Eighth.....	3¼	3.50	6.5	1.25
Ninth.....	3½	3.50	6.5	1.25
Tenth.....	3½	3.50	6.5	1.25
Eleventh.....	3½	3.50	6.5	1.25
Twelfth.....	3¾	3.50	6.5	1.25
Thirteenth.....	3¾	3.50	6.5	1.25
Fourteenth.....	4	3.50	6.5	1.25
Fifteenth.....	4¼	3.75	6.5	1.25
Sixteenth.....	4¼	3.75	6.5	1.25
Seventeenth....	4½	3.75	6.5	1.50
Eighteenth.....	4½	3.75	6.5	1.50
Nineteenth.....	4¾	3.75	6.5	1.50
Twentieth.....	4¾	3.75	6.5	1.50
Twenty-first...	4¾	3.75	6.5	1.50
Twenty-second..	5	3.75	6.5	1.50
Twenty-third...	5	3.75	6.5	1.50
Twenty-fourth..	5¼	3.75	6.5	1.75
Twenty-fifth...	5¼	3.75	6.5	1.75
Twenty-sixth...	5½	3.75	6.5	1.75
Twenty-seventh.	5½	4.00	6.5	1.75
Twenty-eighth..	5½	4.00	7.0	1.75
Twenty-ninth...	5¾	4.00	7.0	1.75
Thirtieth.....	5¾	4.00	7.0	1.75
Thirty-first...	6	4.00	7.0	1.75
Thirty-second..	6	4.00	7.0	1.75
Thirty-third...	6¼	4.00	6.5	1.75
Thirty-fourth..	6¼	4.00	6.5	2.00
Thirty-fifth...	6¼	4.00	6.5	2.00
Thirty-sixth...	6¼	4.00	6.5	2.00
Thirty-seventh.	6½	4.00	6.5	2.00
Thirty-eighth..	6½	4.00	6.5	2.00
Thirty-ninth...	6½	4.00	6.5	2.00
Fortieth.....	6¾	4.00	6.5	2.00
Forty-first....	6¾	4.00	6.5	2.00
Forty-second...	7	4.00	6.5	2.00
Forty-third....	7	4.00	6.5	2.25
Forty-fourth...	7	4.00	6.0	2.50
Forty-fifth....	7	4.00	6.0	2.50
Forty-sixth....	7¼	4.00	6.0	2.50
Forty-seventh..	7¼	4.00	6.0	2.50
Forty-eighth...	7¼	4.00	6.00	2.50
Forty-ninth....	7¼	4.00	6.00	2.75
Fiftieth.....	7½	4.00	6.00	2.75
Fifty-first....	7½	4.00	6.00	2.75
Fifty-second...	7¼	4.00	5.5	3.00

The tabulation in the case of premature infants gives the percentages in rounf numbers next nearest the actual percentages employed; they are approximate and as follows:-

Amount fed.	Fat.	Sugar.	Proteids.
Two to six drachms.....	1.00	3.00	0.25
	1.00	4.00	0.50
	1.50	4.50	0.75

The first laboratory for the exact modification of milk was institutedin Boston, in 1891, under the name of the Walker-Gordon Laboratory, and this and the numerous other similar establishments in various countries enabled medical men to prescribe a food for the infant with the same precision as drugs, so that, if the child does not thrive, he can rest assure that there is something other than the diet at fault. The individual case, however, requires consideration, there being no hard-and-fast prescriptions or formulae available for routine practice. These laboratories are usually to be found in healthy localities (at least the aim should be to have them there), and all possible is done to avoid germ-contamination. The rooms in which the milk is received from the farmers are kept cool, free from dust and isolated as much as possible from the other apartments, and there are usually special remote rooms in which the bottles returned by the customers are sterilised forthwith. The growth of bacteria is inhibited by keeping the appliances under aseptic conditions at a temperature of about 40. F., and only persons solicitous for the success of the establishment are employed. Thus at all seasons of the year a clean milk of unfform percentage can be obtained. As soon as the milk somes into the place, steps are taken to separate it into cream add skim milk, the room for the purpose having structural arrangements ensuring that dust and dirt are properly excluded, and ventilation perfect. With the exception of a small fraction, all the fat is removed by the centrifugal machine, sixteen per cent. being in the resulting cream as determined by a special milk-tester. The prescrptions are dispensed by special employees, each of whom has at hand jars, with tight corks, containing the necessary ingredients, such as cream, separated milk, a special twenty per cent. lactose, fresh lime-water, and oats and barley and wheat. The ordered milk is filled into special feeding bottles, which are stoppered with sterile cotton and placed in baskets for sterilisation. After sterilisation and cooling, the milk is ready for delivery. The following tabulations indicate the various modifications which are effected at such laboratories:

	Low Fats.			
	Per cent.	Per cent.	Per cent.	Per cent.
Fat.....	0.03	0.04	0.08	0.12-0.16
Sugar.....	2.00	3.00	4.00-5.00	6.00-7.00
Proteids.....	0.75	1.00	2.00	3.00-4.00
	Low Sugars.			
	Per cent.	Per cent.	Per cent.	Per cent.
Sugar.....	0.87	1.40	2.12	3.50-4.30
Fat.....	2.00	3.00	3.50	4.00
Proteids.....	0.75	1.00	2.00	3.00-4.00
	Low Proteids.			
Proteids.....	0.22	0.34	0.45	0.53
Fat.....	2.00	3.00	4.00	4.50
Sugar.....	2.00	3.00	4.00-5.00	6.00-7.00

Whey has been of late much used for the modification of milk, it being obtained by the addition of rennin of an essence of pepsin; heating for five minutes to 150. F. is performed for the destruction of the enzyme and obviation of the coagulation of the milk casein. The amount of proteid must be indicated in the prescription when whey is used. When it is desired to split the proteids in infant feeding, Rotch's table of the proportions of whey and casein are useful for reference:

Age.	Fat.	Sugar.	Proteids.	Proteids if split: Whey proteids.	Proteids if split: Casinogen.			
Premature.....	1.00	4.00	0.25	0.25	0.25	½-¾	1-1½	24-18
At term.....	2.00	5.00	0.50	0.50	0.25	1	2	10
End of 2d week.....	2.50	5.50	0.50	0.50	0.25	1½	2	10
End of 3d week.....	3.00	6.00	0.75	0.75	0.25	2	2	9
End of 4th week.....	3.50	6.50	1.00	0.75	0.50	2½	2	8
End of 6th week.....	4.00	7.00	1.00	0.90	0.60	3	2½	7
End of 8th week.....	4.00	7.00	1.25	0.90	0.75	3½	2½	7
End of 12th week.....	4.00	7.00	1.50	0.90	1.00	4	2½	6
End of 4th month	4.00	7.00	1.50	0.75	1.25	4½	2½	6

In the majority of instances whey mixtures are not needed, they being of greatest use in severe cases in which the infant has difficulty in assimilating the proteids; perfect curdling of the casein is necessary in the -se mixtures. Rotch displays the milk laboratory possibilities in this direction as follows:

Fat.	Casein.	Lactalbumin.	Sugar.	Fat.	Casein.	Lactalbumin.	Sugar.
1.00	0.25	0.25	4-7	2.50	0.25	0.50	4-7
1.00	0.25	0.50	4-7	2.50	0.25	0.75	4-7
1.00	0.25	0.75	4-7	2.50	0.50	0.50	4-7
1.00	0.50	0.25	4-7	2.50	0.50	0.75	4-7
1.00	0.50	0.50	4-7	2.75	0.25	0.25	4-7
1.00	0.50	0.75	4-7	2.75	0.25	0.50	4-7
1.50	0.25	0.25	4-7	2.75	0.25	0.75	4-7
1.50	0.25	0.50	4-7	2.75	0.50	0.50	4-7
1.50	0.25	0.75	4-7	2.75	0.50	0.75	4-7
1.50	0.50	0.25	4-7	3.00	0.25	0.25	4-7
1.50	0.50	0.50	4-7	3.00	0.25	0.50	4-7
1.50	0.50	0.75	4-7	3.00	0.25	0.75	4-7
2.00	0.25	0.25	4-7	3.00	0.50	0.25	4-7
2.00	0.25	0.50	4-7	3.00	0.50	0.50	4-7
2.00	0.25	0.75	4-7	3.00	0.50	0.75	4-7
2.00	0.50	0.50	4-7	3.50	0.25	0.50	4-7
2.00	0.50	0.75	4-7	3.50	0.25	0.75	4-7
2.25	0.25	0.25	4-7	3.50	0.50	0.50	4-7
2.25	0.25	0.50	4-7	3.50	0.50	0.75	4-7
2.25	0.25	0.75	4-7	4.00	0.25	0.25	4-7
2.25	0.50	0.50	4-7	4.00	0.25	0.50	4-7
2.25	0.50	0.75	4-7	4.00	0.25	0.75	4-7
2.25	0.75	0.50	4-7	4.00	0.50	0.25	4-7
2.25	0.75	0.75	4-7	4.00	0.50	0.50	4-7
2.50	0.25	0.25	4-7	4.00	0.50	0.75	4-7

Holt has devised a system of weekly reports on the children fed from these laboratories, the mother receiving a quantity of blank sheets, filling them in, and forwarding them every seven days to the medical attendant. The reports provide for the name and age of the child, with address; weight and gain since last report; number and colour of the stools and their consistence; vomiting and regurgitation, when and to what extent occurring; flatulence or colic; appetite and if the child seems satisfied after a feed; if good tempered and comfortable; duration of sleep; general remarks; date of present and last report. The average percentages of proteids, fat, and carbohydrates have been tabulated on p. 142 and should be borne

in mind,the amount of milk to be increased about half an ounce at a time according to indications.Later the percentages of the various constituents may be augmented, the fat about half a per cent. the proteids from a half to a per cent.,and the proteids from 0.1 to 0.25 per cent.at a time.Dissatisfaction after a meal is a good sign that a richer milk is needed.Ssnitkin bases the amount of the feeds on thw eight of the child,as he found that an infant's stomach holds about one-hundreth of its weight at birth and that the increase amounted to about a gramme per diem.He ascertains the average amount required for each meal by taking one-hundreth of the initial weight at birth and adding a gramme for each day of its existance.

Top-milk Mixtures.

These are specially directed towards increasing the percentage of fat at a greater rate than the proteids,it being assumed that cow's milk contains four per cent.of fat.There are various methods which can be used at home, that of Holt being perhaps the best, and a certain amount of intelligence must be presumed on the part of the mother for the success of the undertaking. The advantages of the top-milk method are that extra fat need not be added;there is no risk of spoiling or contaminating fresh milk with old or stale cream or one too rich in fat;and a tolerable accuracy in percentages can be secured. On the other hand,it must be noted as objections that any excess of fat will crowd out the proteids, and that the lower the latter will be the more cream the milk contains. It is necessary to see that the milk used shall be pure and as uniform in quality as possible,and some sort of confirmatory analysis should be made or procured from the vendor.The jar of milk is allowed to stand for some time,and then the mixture of cream and milk in the upper third or upper half is used, it being necessary,however,to see that the milk is bottled soon after milking before the cream has had time to separate:otherwise the necessary mixture of cream and milk may be prepared according to table presently to be given.The top layer of cream may be removed from the bottle by an ordinary spoon and the remainder by means of a small dipper or the special appliance known as Chapin's dipper;some,however,prefer to use a siphon.The method of using the upper third is not so satisfactory as the other;thorough mixing shouldbe performed prior to use.Milk-sugar may be added by allowing two and a half level tablespoonfuls to the ounce,and half that quantity if cane-sugar be used,dry measure being doublethat of weighing in the case of sugar.Holt(Diseases of Infancy and Childhood,pp.189,191,192)is responsible for the following figures and tabulations:

First Series of Formulas.-Fat to Proteids, 3 : 1

Primary Formula.- Ten per cent. milk - fat, 10 per cent.; sugar, 4.3 per cent.; proteids, 3.3 per cent. Obtained - (1) as upper one third of bottled milk or (2) equal parts of milk and 16 per cent. cream.

Derived formulas, giving quantities for 20 ounce mixtures:

		Fat %	Sugar %	Proteids %
1.	Milk-sugar... 1 oz.; Lime-water... 1 oz.; Water, q.s.ad 20 oz. with 2 oz. 10% milk	1.00	5.50	0.33
2.	" " " " 3 "	1.50	5.50	0.50
3.	" " " " 4 "	2.00	6.00	0.66
4.	" " " " 5 "	2.50	6.00	0.83
5.	" " " " 6 "	3.30	6.00	1.00
6.	" " " " 7 "	3.50	6.50	1.16

Table Giving in a Condensed Form the Quantities Usually Required for Obtaining the Different Fat-Percentages.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
To obtain fat, per cent.	0.50	1.0	1.5	2.0	2.0	2.5	2.5	2.75	3.0	3.0	3.0	3.25	3.5	37	40
For total food, ounces.	0.20	20.0	20.0	20	25	25	28	28	30	33	36	36	37	38	40
Take 10 per cent. milk, ounces.	0.10	2	2	4	5	6	7	8	9	10	11	12	13	14	16

Proteids: The percentage in each case will be one-third fat.

Sugar: 1 ounce in 20, or 1 tablespoonful in 8 ounces, gives 5.5 per cent. for the lower and 6.5 for the higher formulas.

Lime-water: 1 part to 20 of the food, the average required.

Water: Sufficient to be added to the foregoing ingredients to bring the total to the number of ounces specified; in part of this water the milk-sugar is dissolved. Barley-water or any other diluent may be added in the same manner.

Second Series of Formulas - Fat to Proteids, 2 : 1

Primary Formula.- Seven per cent. milk - fat, 7 per cent.; sugar, 4.4 per cent.; proteids, 3.5 per cent. Obtained - (1) as upper one-half of bottled milk, or (2) by using 3 parts of milk and 1 part of 16 per cent. cream.

Derived formulas, giving quantities for 20-ounce mixtures:

		Fat %	Sugar %	Proteids %
1.	Milk-sugar....., Lime-water.....with 3 oz. 7 p.c. milk, Water, q.s.ad 20 oz.	1.00	5.50	0.50
2.	" " " " 4 " " "	1.40	5.75	0.70
3.	" " " " 5 " " "	1.75	6.00	0.87
4.	" " " " 6 " " "	2.10	6.00	0.05
5.	" " " " 7 " " "	2.50	6.50	1.25
6.	" " " " 8 " " "	2.80	6.50	1.40
7.	" " " " 9 " " "	3.15	7.00	1.55
8.	" " " " 10 " " "	3.50	7.00	1.75
9.	Milk-sugar....¾ oz., Lime-water....1 oz., Water, q.s.ad 20 oz. " 12 " " "	4.00	7.00	2.00

Table Giving in Condensed Form the Quantities Usually Required for Obtaining the Different Fat-Percentages.

	A	B	C	D	E	F	G	H	I	J	K	L	M
To obtain fat, per cent.	1.0	1.0	1.4	1.8	2.0	2.33	2.75	2.75	3.1	3.5	3.5	4.0	4.0
For total food, ounces.	20	30	30	33	33	36	36	40	40	40	44	44	48
Take 7 per cent. milk, ounces.	3	4	6	8	10	12	14	16	18	20	22	25	28

To obtain the exact fat-percentage take one-third the number of ounces of top-milk in a 20-ounce mixture and add 0.15 to the result. In practice this slight error may be disregarded.

Proteids: The percentage in each case will be equal one-half of the fat.

Sugar: 1 ounce in 20, or 1 even tablespoonful in 8 ounces, until the food becomes half milk; after that 1 ounce in 25, or 1 even tablespoonful to each 10 ounces of the food, will give the proper amount.

Lime-water: Usually in the proportion of 1 part to 20 of the total food.

Water or other diluent: Sufficient to be added to the foregoing ingredients to make the total number of ounces specified; in part of this the sugar is dissolved.

Third Series of Formulas - Fat to Proteids, 8 : 7

Primary Formula.- Plain milk - fat, 5 per cent.; sugar, 4.5 per cent.; proteids, 3.5 per cent.

Derived Formulas, giving quantities for 20-ounce mixtures:

		Fat %	Sugar %	Proteids %
1.	Milk-sugar....1 oz.; Lime-water....1 oz.; Water q.s.ad 20 oz. with 5 oz. plain milk	1.00	6.00	0.87
2.	" " " " 6 " "	1.20	6.00	1.00
3.	" " " " 8 " "	1.60	6.50	1.40
4.	" " " " 10 " "	2.00	7.00	1.75
5.	Milk-sugar ½ oz.; Lime-water ½ oz.; Water q.s.ad 20 oz. " 12 " "	2.40	5.00	2.10
6.	" " " " 14 " "	2.80	5.50	2.50
7.	" " " " 16 " "	3.20	5.50	2.80

Table Giving Quantities of 16 per cent. Milk Required for Obtaining Formulas with High Fat and Low Proteids.

	A	B	C	D	E	F	G	H	I	J	K
To obtain fat, per cent.	1.6	1.6	2.0	2.5	3.0	3.0	3.0	3.5	3.5	4.0	4.0
For total food, ounces.	20	30	30	32	32	37	42	36	40	40	44
Take 16 per cent. milk, ounces.	2	3	4	5	6	7	8	8	9	10	11

Proteids in all cases will be one-fifth the fat.

Sugar: 1 even tablespoonful for each 8 ounces will

give 5.5 per cent.for the lower formulas (A,B,C,etc.) and 6 per cent.for the higher formulas (G,H,I,etc.).

Lime-water: 1 ounce to 20 ounces of the food will give 5 per cent.

There seems a idea amongst the nursing public that to properly feed an infant artificially it is merely necessary to dilute cow's milk with an equal part of water,giving two per cent.of fat and the same amount of sugar,and also of proteids;and then adding two per cent. of fat and five per cent.of sugar to make the proportions four per cent.of fat,seven per cent.of sugar,and two per cent.of proteids - which,as we have seen,is the approximate composition of breast milk.And this would be a proper food but for the fact that the proteids of cow's milk differ materially from those of the mother's milk as regards digestibility,requiring their considerable dilution before the child can assimilate them.When the infant is about twelve weeks of age its digestion has become accustomed to cow's milk proteids,the proportions of which should have been gradually increased from from to time until the formula is identical with that of the maternal secretion.In general,then,it will be found convenient in manufacturing a milk for a baby under three months to use,as a basis of the dietary,cow's milk which contains,say,twelve per cent.of fat,and four per cent. each of carbohydrate and proteids.This we may term a twelve per cent.milk or 12-4-4 milk.If the infant is from three to nine months of age,it is desirable to make use of a cow's milk containing eight per cent.of fat and four per cent.each of carbohydrate and proteids.This we may term an eight per cent.milk or 8-4-4 milk. The four per cent.milk or the 4-4-4 milk may be taken to conveniently designate ordinary cow's milk,which,as has been mentioned,contains four per cent.each of fat,carbohydrate and proteids.For the preparation of an eight per cent.or twelve per cent.milk the simple procedure of adding to ordinary mixed 4-4-4 milk the necessary amount of fat,in the form of cream,is alone required.Cream is merely milk with an excess of fat;the gravity cream and the centrifugal are the two varieties of it.The gravity cream contains sixteen per cent.of fat,and four per cent. each of carbohydrate and proteids;it is the cream which rises to the top of a milk bottle or which may be skimmed from the milk pans.But rhe centrifugal cream is prepared with a special centrifugal machine,and is sold in small bottles in the shops as cream.It contains twenty per cent.of fat and four per cent.each of sugar and proteids;it is of thick consistence and much used in hotels and public eating-houses.To make either eight per cent.or twelve per cent.milk,to proper amount of either gravity or centrifugal cream must be added;and for this purpose the following formulae should be borne in mind:

Fat. Per cent.	Sugar Per cent.	Proteids. Per cent.
4	4	4
8	4	4
12	4	4
16	4	4
20	4	4

From the above it will be seen that the fat is the only variable constituent, but that it does so in the regular arithmetical progression of four,eight,twelve, sixteen and twenty.Reading along the line,it will be

observed that the first formula (4-4-4)is that of ordinary milk,that the next two (8-4-4, and 12-4-4)are those of the desired products for use as the basis of the infant's food,while the common forms of cream are represented by the last two (16-4-4 and 20-4-4).In addition to the plan of making eight per cent.or twelve per cent. milk by mixing cream and ordinary milk in due proportions, the same end is achieved by taking away a definite quantity of milk from the top of an ordinary quart bottle in which the cream has stood long enough to rise.This is the top-milk method already referred to.The gravity-cream, the centrifugal-cream and the top-milk are,therefore, three convenient methods at our disposal.The twelve per cent.milk made be prepared from gravity cream by the addition thereto of one part of 4-4-4 milk as follows:

	Fat.	Sugar.	Proteids.
	16	4	4
	16	4	4
	4	4	4
3)	36	12	12
	12	4	4

It may likewise be prepared from centrifugal cream by mixing with it equal parts of 4-4-4 milk as follows:

	Fat.	Sugar.	Proteids.
	20	4	4
	4	4	4
2)	24	8	8
	12	4	4

Or we may use the top milk,removing nine ounces from the top of the bottle as it comes to hand.This,as stated,can conveniently be done by Chapin's dipper.In order that the milk may not slop over when the dipper is lowered into the bottle,the first dipperful should be removed with a spoon;further,the milk must be dipped out and not poured,otherwise the proportion of fat in the top milk will be altered by any tipping of the bottle.We have already seen that the maternal milk is either neutral or alkaline in reaction;but cow's milk is always acid by the time it is delivered,so that it should not be given to the infant before lime-water is added.Maternal milk contains seven per cent,of sugar,whereas there is four per cent.in the like secretion of the cow,and the addition of water required to reduce the fat and proteids to a proper proportion reduces the sugar to a negligible quantity,so that the infant's food must be given an attractive sweetness with ordinary sugar or the milk variety.In the case of a baby under three months of age,it is,when twelve per cent.milk forms our basis, necessary only to add lime-water,milk-sugar and water in due proportionsThe quantities of lime-water and sugar are subject to no variations,but as the child becomes older and able to assimilate a stronger food,the milk must be increased and the water proportionately diminished.It is usually convenient to prepare twenty ounces of food at a time;for this we require one ounce each of lime-water and milk-sugar.A sufficiency of hot water is added to make the total amount of food up to twenty ounces after the addition of the quantity of twelve per cent.milk suited to the age of the child.The following table is useful for reference;the last formula in it, containing 3.60 of fat,six per cent.of sugar,and 1.20 of proteids,is nearly the same as the maternal four per cent.fat,seven per cent.sugar and two per cent.proteids;and the child is general able to assimilate milk

of the latter strength from the commencement of the time that it is about sixteen weeks of age:

Age.	Lime-water	Milk-sugar	12 % Milk	Boiled water	Result. Fat	Sugar	Proteids
Second day.....	℥i	℥i	℥ii	.ʒp	1.20	5%	.20%
Third to fourth day.....			℥iii	℥o	1.20	5%	.40%
Fourth to seventh day....			℥iii	i	1.80	6%	.60%
Seventh to thirtieth day.			℥iv	3	2.40	6%	.80%
Second month.....			℥v	xx	3	6%	1 %
Third month.....			℥vi		3.60	6%	1.20

The eight per cent.milk is more easily manipulated than the twelve per cent.,and will therefore be found in practice convenient for preparing the imitation of the maternal secretion with its proportions of four to seven to two.Like the twelve per cent.milk,it may be prepared from either the gravity cream,the centrifugal cream or the top milk.If gravity cream be used,there must to it be added two parts of 4-4-4 milk, as follows:

	Fat.	Sugar.	Proteids.
	16	4	4
	4	4	4
	4	4	4
3)	24	12	12
	8	4	4

If centrifugal cream be used,to it must be added three part of the 4-4-4 milk,as follows:

	Fat.	Sugar.	Proteids.
	20	4	4
	4	4	4
	4	4	4
	4	4	4
4)	32	16	16
	8	4	4

In the case of the top milk method there must be taken from the full bottle sixteen ounces of the same by means of the above-mentioned dipper. For the modification of the eight per cent.milk it is necessary only to dilute it a half with hot water,which reduces the constitution to four percent fat and two each of sugar and proteids, and then make the ingredient seven per cent.by the addition of five per cent.of sugar.In the case of an infant from the fourth to the ninth month there must be used, for the preparation of twenty ounces of food,one ounce each of lime-water and milk-sugar and nine ounces of boiled water,which will result in four per cent.of fat, seven per cent.of sugar and two per cent.of proteid - that is,a milk of the same percentage composition as breast milk.

In the "Archives of Pediatrics," 1898 (p.342), Coit described his decimal method, which,he says,has the advantages of being easily remembered and convenient of application.He uses a decimel or ten per cent.cream, a saccharated skim-milk for introducing proteids not carried by the cream,and a standard solution of sugar for introducing lactose not carried by the cream or skim-milk.During the first few months of the infant's existence only the decimal cream and the saccharine solution are needed.The ten per cent,cream is best obtained by allowing a bottle of milk to stand for fifteen hours,the upper six ounces of each quart,when

mixed with half its volume of sterile water, furnishing the necessary strength. Out author gives the following table to demonstrate the differences in this gravity cream, top-milk and centrifugal cream:

Percentage Composition of Decimal Cream.

	Fat.	Protein.	Lactose.	Water & Salts.
No.1. Gravity.....	10.0	2.33	2.66	85.01
No.2. Top-milk.....	10.0	3.75	4.50	81.75
No.3. Centrifugal...	10.0	1.50	2.00	86.50

The same author also gives a tabulation of the approximate percentages of proteid and lactose contained in these decimal creams, the same being useful for reference when into the infant's food it is desired to introduce certain amounts of fat; it is as follows:

Formulas.

No.1. Gravity cream, 180 c.c. (6 fl.oz.) + water, 90 c.c. (3 fl.oz).
No.2. Top-milk, including gravity cream, 300 c.c. (10 fl.oz.).
No.3. Centrifugal cream, 20 per cent. fat + water, equal volumes.

		Per cent.	Also carries - Protein, Per cent.	Lactose, Per cent.
Decimal cream No.1	For introducing milk-fat,	4.0 ..	1.0	1.0
	" " "	3.5 ..	0.8	0.9
	" " "	3.0 ..	0.7	0.8
	" " "	2.5 ..	0.6	0.7
	" " "	2.0 ..	0.5	0.5
Decimal cream No.1	For introducing milk-fat,	4.0 ..	1.5	1.8
	" " "	3.5 ..	1.3	1.6
	" " "	3.0 ..	1.1	1.4
	" " "	2.5 ..	0.9	1.2
	" " "	2.0 ..	0.7	0.9
	For introducing milk-fat,	4.0 ..	0.60	0.8
	" " "	3.5 ..	0.50	0.7
	" " "	3.0 ..	0.45	0.6
	" " "	2.5 ..	0.40	0.5
	" " "	2.0 ..	0.30	0.4

Coit prepares the standard skim-milk by the addition to one litre of skim-milk of fifty grammes of milk-sugar, which represents the propoprtion of one ounce in twenty. The formula of the skim-milk is four per cent. proteids and five per cent. sugar, or a ratio of five to four. It is easy enough to supply the proteids, a given amount of food multiplied by 0.25 indicating a quarter of its bulk, adding to the mixture, if skim-milk, one per cent. of proteid; the same decimal multiplier would indicate the percentage of sugar thus introduced by a ten per cent. solution. The lactose contained in the saccharated skim milk cooresponding to definite protein values is shown in the following tabulation:

	Saccharated skim-milk.
Amount of food in c.c. × 0.125 or $\frac{1}{8}$ =	Protein 0.5 Lactose 1.25
Amount of food in c.c. × 0.250 or $\frac{1}{4}$ =	" 1.0 " 2.50
Amount of food in c.c. × 0.375 or $\frac{3}{8}$ =	" 1.5 " 3.75
Amount of food in c.c. × 0.500 or $\frac{1}{2}$ =	" 2.0 " 5.00

It is easy enough to prepare the standard saccharine solution by dissolving one hundred grammes of lactose in enough water to make a litre, or in proportion of two ounces by weight to twenty ounces of water. But if the sugar be impure, there is a risk of precipitating the casein of the milk, and this should always be obviated by seeing that contains no free lactic acid. If we bear in mind the percentage formula desired, the amount of food required, and that the standards, except for the protein, represent percentages in ratio of one to ten, the formulas can be calulcated without difficulty and the

percentage composition readily adjusted.The quantity of food required should be reduced to cubic centimetres, which is done by multiplying ounces by thirty,and this product multiplied by the percentage tenth of the element to be introduced gives the required figure.In illustration of this various tables have been published,which need not be reproduced here.

A reliable and not too complicated method much used by American practitioners is the materna graduate,being specially devised for cases in which the home facilities are not good and where it is difficult to effect the necessary milk modifications.It has six formulas,which may have to be adapted according to requirements.The necessary appliances are a glass jar with a lip and seven panels,also a capacity of sixteen ounces.One of the panels is graduated in ounces,the other six showing that number of different formulas for the modification of cow's milk,each formula being devised to keep pace with the development of the infant;thus:

Fat.....2 per cent.	2½ per cent.	3 per cent.	3½ per cent.	4%	3½%
Sugar.....6 "	6 "	6 "	7 "	7"	3½"
Protein...0.6 "	0.8 "	1 "	1½ "	2"	2½"

The sixth formula will presently be described.

	3d to 14th day	2d to 6th week	6th week to 11th week	11th week to 5th month	5th to 9th month		9th to 12th month.
Milk.....parts	1¼	1⅝	2	4½	6	Milk.....parts	9¾
Cream..... "	1¼	1⅜	2	2	2	Cream..... "	1
Lime-water "	1	1	¾	¾	¾	Barley-gruel "	5¼
Water..... "	12½	11¾	11¼	8¾	7½	Granulated sugar, parts.....	¼
Milk-sugar "	1	1	1	1	1¼		

The panel containing the desired formula is now the only one to be taken into consideration;after that the apparatus must be filled with the twenty-four hours' supply - thus: if sixteen ounces or less are needed during that period,it is filled once, twice if from sixteen to thirty-two ounces are needed,and thrice if from thirty-two to forty-eight ounces will constitute the day's supp-ly.The directions for using this Estraus Maternal Graduate Method are as follows:

"1. Milk-sugar.- Introduce milk-sugar to the line so marked(the lines underneath the words indicate the points to which the various ingredients are to be filled in).Where good milk-sugar can not be obtained,granulated sugar,in just half the quantity,should be used.A small cross on the apparatus indicates this point.(See directions for Formula 6.)

2. Water.- Add boiled water (hot) to the water-mark, and stir until the sugar is dissolved.If any particles are seenfloating in the solution,it should be filtered either through absorbent cotton or through two thicknesses of clean muslin.

3. Lime-water.- Ordinary lime-water,such as is obtained at drug-stores,should then be filled to the L-water mark.

4. Cream.- This should be the ordinary cream (16-20 per cent.)as obtained in bottled milk;it should be poured in to the cream mark.If the cream is purchased separately,ordinary cream,and not cnetrifugal cream,should be used.

5. Milk.- Ordinary good cow's milk should be used and the jar filled to the milk mark.

6. The entire mixture should next be stirred.

7. The whole should then be poured into separate bottled and sterilised if desired,or stoppered with cotton and immediately placed on ice.

Directions for Formula 6. - 1.Sugar.- In this formula granulated sugar should be used in place of milk-sugar,and the sugar introduced into the vessel to the line thus marked.

2. Barley-gruel.- In this formula barley-gruel should be used instead of water,and the glass filled to the line thus marked.Barley-gruel should be prepared as follows: To 1 tablespoonful of pearl barley,after soaking for several hours,add 1 pint of water,a pinch of salt,and boil for five or six hours,adding water as necessary.Strain through muslin.Or the following method may be used: 1 rounded tablespoonful of Robinson's barley flour;rub up with cold water,and add to 1 pint of boiling water;cook for fifteen minutes,stir,and strain if lumpy.

3. Cream. 4. Milk.- Add the same as in the other formulas. 5. Stir. 6. Sterilise.- Same as in other formulas."

Maynard Ladd's tables aresometimes used for the modification of milk in hospitals where there is a proper laboratory;but they are practically useless for general practice,being difficult to remember and having to be carried about.The y are published in Rotch's "Pediatrics," and in suitable columns indicate the fats,sugar and proteids in prescriptions calling for a mixture of twenty ounces;the cream in ounces in ten,twelve,sixteen,and twenty per cent.,with percentage of lime-water;the fat-free milk in ounces used with creams of the percentages just mentioned;the lime-water and the boiling water in ounces;also the milk-sugar in measures.

Baner's method attempts to arrange a table of equations from which the quantities of milk,cream,etc.,may be determined for an given mixture.The equations concern the quantity desired in ounces,the desired percentage of fat,the desired percentage of sugar,and the desired percentage of protein - by the use of which the cream(sixteen per cent.),the milk,the water,and the dry milk-sugar can be arranged.

Starr has devised a table for the modification of milk in which percentages are objected to,ounces being the quantities considered.It is not,however,entirely satisfactory.

Chapin(Infant Feeding)is the originator of the method consisting of the removal,by means of a one-ounce dipper,of the top-milk or cream from bottled milk, this being done as soon as the milk has come to hand if the cream has separated.In the case of young infants,he advises the removal of nine ounces from the top of a quart of milk,the ratio of fat to proteid being three to one.In the case of older infants sixteen ounces should be removed,the ratior of fat to proteid being two to one. Chapin dilutes this with wheat-, barley-, rice-, or oatmeal-water,using one or two tablespoonfuls of flour and a quart of water,and boiling for fifteen minutes. This may be dextrinised,strained,and salted ot sweetened to taste,if necessary.He publishes the following table:

Progressive Increase of Quantity and Strength of Mixtures.

16 ounces - one-eighth top-milk. Eight 2-oz. feedings, one every two hours.	2 oz. of 9-oz. top-milk (after being removed from bottle and mixed). 14 oz. of diluent. 1 oz. of sugar.
21 ounces - one seventh top-milk. Eight 2½-oz feedings, one every two hours.	3 oz. of 9 oz. top-milk (after being removed from bottle and mixed). 18 oz. of diluent 1 oz. of sugar
24 ounces - one-sixth top-milk. Seven 4-oz. feedings, one every two and one-half to three hours.	4 oz. of 9-ounce top-milk (after being removed from bottle and mixed). 2 oz. diluent. 1 oz. sugar.
30 ounces - one-fifth top-milk. Seven 4-oz. feedings, one every two and one-half to three hours.	6 oz. of 9-oz. top-milk (after being removed from bottle and mixed). 24 oz. diluent. 1½ oz. of sugar.
36 ounces - one-fourth top-milk. Six 6-oz. feedings, one every three hours.	9 oz. of top-milk from one quart bottle. 27 oz. of diluent. 1½ oz. of sugar.
42 ounces - one-third top-milk. Six 7-oz feedings, one every three hours.	14 oz. of top-milk from one quart bottle. 28 oz. of diluent. 2 oz. of sugar.
40 ounces - one-half top-milk. Six 7-oz. or five 8-oz. feedings, one every three to three and one-half hours.	20 oz. of top-milk from one quart bottle. 20 oz. of diluent. 1 oz. of sugar.
48 ounces - two-thirds top-milk. Six 8-oz. or five 10-oz. feedings, one every three and one-half hours.	1 quart of milk. 1 pint of diluent.

The composition of the mixtures is displayed by our author in the following table:

9-oz top-milk	Lowest extreme. 9-oz top-milk from milk 3 per cent. fat.			Highest extreme. 9-oz top-milk from milk 5 per cent. fat.		
	Fat %	Protein %	Sugar %	Fat %	Protein %	Sugar %
Diluted 8 times	1.10	0.38	0.50	2.00	0.50	0.50
" 7 "	1.30	0.43	0.67	2.30	0.57	0.57
" 6 "	1.50	0.50	0.67	2.67	0.67	0.67
" 5 "	1.80	0.60	0.80	3.20	0.80	0.80
" 4 "	2.25	0.75	1.00	4.00	1.00	1.00
" 3 "	3.00	1.00	1.33	5.60	1.33	1.33

Chapin also points out that the richness of the original milk will determine the exact composition of the mixtures, which cannot therefore be indicated on hard-and-fast lines in advance; he adds that, without the solids of the diluent and the sugar, the range of composition will invariably come within the following limits:

	Lowest extreme. 16-oz top-milk from milk 3 per cent. fat.			Highest extreme. 16-oz top-milk from milk 5 per cent. fat.		
	Fat %	Proteids %	Sugar %	Fat %	Proteids %	Sugar %
Diluted 8 times	0.7	0.38	0.50	1.12	0.50	0.50
" 7 "	0.8	0.43	0.57	1.30	0.57	0.57
" 6 "	0.9	0.50	0.67	1.50	0.67	0.67
" 5 "	1.1	0.60	0.80	1.80	0.80	0.80
" 4 "	1.4	0.75	1.00	2.25	1.00	1.00
" 3 "	1.8	1.00	1.33	3.00	1.33	1.33
" 2 "	2.7	1.50	2.00	4.50	2.00	2.00

Proprietary Foods.

There are a large number of proprietary infant-ile foods(sic)on the market all claiming to be efficient substitutes for the maternal milk supply.So far as my experience goes,they are all more or less unsatisfactory,and in not a fee instances I have ascribed the production of rickets directly to to their abuse,that is,their constituting the entire diet of the infant.They are by no means,it would seem,constant in their composition,deficient in fat and lime salts,and comparatively more expensive than the other preparations already described;the starchy preparations,in which the amylaceous material has not been predisgested,have perhaps the least dietetic value of all,and in not a few there is too little fat and far too much sugar.Owing to their being a prolific cause of rickets and infantile scurvy, they should never be used until all other maternal-milk substitutes have been tried and failed.They are,it is true,handy,sterile,and have their proteids in a more assimilable form than in cow's milk."When children are fed",observes Holt(loc.cit.)upon foods lacking in fat the teeth come late,the bones are soft,the muscles flabby", while"children fed on foods containing too much sugar are frequently very fat,but their flesh is very soft; they walk late and they perspire readily about the head and neck".Further,as Halliburton(Dietetic Value of Patented Foods,N.Y.Med.Jour.,Jan.23,1904)remarks,"mere chemical analysis is no criterion of food-value,for the digestibility of the food is the all-important question. Investigations into the value of food-stuffs must be conducted and controlled both in vivo and in vitro - both in the body and in the test-tube.The results of test-tube experiments are of value,but the final test of food-stuffs must be made on animals,and preferably on man.These experiments are both tedious and difficult, but there is a growing appreciation of their value and increasing resort to their use".Proprietary foods are divided by Hutchinson(Food and Dietetics,p.445)into the following three categories:

1. Foods prepared from cow's milk with various additions or alterations,and requring merely the addition of water to make them ready for immediate administration to the child.This class included such foods as Malted Milk, Nestlé's Food,Lactated Food,Carnick's Food,Cereal Milk,Wyeth's Prepared Food,and Wampole's Milk Food.They are manufactured from flour baked and mixed with milk or creamand then dried,added malt changing the starches into dextrin and maltose.They contain usually about the following percentages of ingredients:water 90 per cent.;

proteids one per cent.;fat half a per cent.;sugar five per cent.;and half a per cent.of mineral matter.Chittenden (N.Y.Med.Jour.,July 18,1896)estimates the composition of Malted Milk and of Nestlé's Food as follows:

	Malted Milk.	Nestlé's Food.
Water	92.40	92.76
Proteids	1 .15	0.81
Fat	0.60	0.36
Sugar	5.38	3.80
Mineral matter	0.29	0.13

2. Farinaceous foods prepared from cereals of which the starch has been partly or wholly converted into dextrin or sugar,and which need the addition of milk before they can be administered.In this category he includes such products as Mellin's Food,Savory & Moore's Infant Food,and Benger's Food.They are manufactured by mixing equal parts of wheat flour and barley malt with bran and potassium bicarbonate,the whole being made into a paste with water and kept warm until the starch is changed into dextrin and maltose.They are added to milk to render them more nutritious,as they are poor in fat,proteids and mineral matter.

3. Farinaceous foods in which the starch has not been predigested,including Ridge's Food,Neave's Food, Imperial Granum,and Robinson's Patent Barley.Being poor in fat,proteids and mineral matter,their administration requires careful consideration.

Cautley(loc.cit.,p.268)classifies proprietary foods as follows:

GROUP I. Foods prepared from cow's milk:
- (a) Condensed milk,without added sugar.
- (b) Condensed milk with added sugar.
- (c) Peptonised milk.

GROUP II. Foods prepared from cow's milk and modified cereals;the starch unchanged or partially converted into dextrin,etc.
- (a) Containing much unchanged starch,-e.g.,Nestlé's, Anglo-Swiss,etc.
- (b) The starch largely converted into soluble carbohydrates,such as maltose and dextrin,-e.g., Allen and Hanbury's.
- (c) Milk foods in which the milk has been partially peptonised or contains ferments which act on the addition of warm milk,and containing partially or entirely converted or unconverted starch,-e.g.,Benger's(prepared with milk),Carnick's,Horlick's Malted Milk.

GROUP III. Foods prepared from modified cereals only.
- (a) The starch unchanged,-e.g.,Robinson's Prepared Barley,Frame's Food,Ridge's Food,Neave's Food.
- (b) The starch partially changed by the action of malt diastase,-e.g.,Savory & Moore's Food.
- (c) The starch completely changed,-e.g.,Mellin's Food,Horlick's Food.

Allenbury has three dietetic preparations,which are perhaps the best of their kind,though rather expensive. They are the No.1 for infants up to three months;the No. 2 for use up to six months;and the No.3 for babies after the latter age.The No.2 contains a small quantity of malt extract,and the No.3 is a malted starch food which needs to be mixed with milk prior to use.The composition of

the No.1 food is, according to the "Lancet," as follows:

	No.1 Food.	Diluted 1-8 by weight.
Fat.....	13.15	1.64
Lactose and dextrin	65.48	8.19
Proteids.....	14.25	1.78
Salts.....	4.75	0.6
Total solids	101.63	11.67

Leeds has analysed various proprietary foods to the following effect (in percentages):

Name of Food.	Water	Albumin-oids	Fats	Starch	Soluble carbohydrates	Ash	Gum cellulose, etc.	Remarks.
Wheat flour	9.02	7.47	1.01	76.07	6.66	...	...	.....
Wheat baked	7.78	under-determined	0.41	67.00	14.29	...	...	Albuminous substances are more soluble
Robinson's Patent Barley.....	10.10	5.13	0.97	76.77	4.11	1.93	1.33	.....
Ridge's Food.....	9.23	9.24	0.63	77.96	5.19	0.60	...	Cane-sugar, 2.20. Grape-sugar, 2.40. Almost pure flour.
Nestlé's Food.....	5.00	11.00	4.25	36.86	40.91	1.70	0.28	The soluble carbohydrate is almost all cane-sugar.
Anglo-Swiss Condensed Milk.....	6.50	10.26	4.91	29.48	46.43	2.02	0.40	Much cane-sugar.
Franco-Swiss Condensed Milk....	4.43	13.00	3.70	30.86	46.09	1.42	0.50	Much cane-sugar.
American-Swiss Condensed Milk..	5.68	10.54	5.81	30.00	45.35	1.21	0.41	Much cane-sugar.
Malted Milk.....	2.18	15.83	5.30	5.57	66.99	3.13	...	.....
Wells & Richardson-'s Food....	7.76	11.85	1.64	36.43	39.00	2.61	0.71	.....
Savory & Moore's Food.....	8.34	9.63	0.40	36.36	44.83	0.89	0.40	Much grape- and cane-sugar.
Horlick's Food.....	9.70	10.43	0.34	....	76.83	2.20	0.50	.....
Mellin's Food.....	12.37	10.07	0.18	....	68.18	3.75	5.45	About half soluble carbohydrate is grape-sugar.
Imperial Granum....	8.38	14.13	1.4	76.11	1.80	0.39	...	.....
Lacto-preparata.....	5.80	14.51	12.-35	.....	63.68	3.66	..	.....
Carnick's Food.....	3.42	10.25	7.45	37.37	27.08	4.42	..	.....

The above figures are subject to wide variation, as is evident from the results of other analysts; there appears to be no constancy about the proportions of their ingredients.

James Knight (Report, Conference on Infantile Mortality) gives the following analyses of various foods made with a milk of 1032 specific gravity and containing

3.6 per cent.proteid,four per cent.fat,and 5.37 per cent. lactose:

Neave's Food.- Basis of oat flour;free starch present:

	Proteid.	Fat.	Carbohydrate.
Dry food.....	12.10	0.86	82.03
With water.....	0.78	0.005	5.40

(Vague directions for use with milk.)

Benger's Food.- Pancreatised wheaten flour;free starch;48½ per cent.soluble material:

	Dry Food.	Prepared. Milk 1; water 2.
Proteid.....	12.48	2.1
Fat.....	0.86	1.8
Carbohydrate.....	76.91	6.2

Frame's Food.- Biscuit basis with malt:

	Dry Food.	Prepared. Milk 1; water 2.
Proteid.....	19.86	4.5
Fat.....	Trace.	1.1
Carbohydrate.....	76.54	14.49

Mellin's Food.- Starch is here reduced to almost pure dextrin:

	Dry Food.	Prepared for three months.
Proteid.....	10.01	1.63
Fat.....	0.08	1.22
Carbohydrate.....	78.86	5.36

Allenbury's Foods.- No.1 a dried modified milk and No.3 a starch-containing malted food. No 2 is composed of milk and deposits fat on standing:

	Dry Food.	Prepared.
Proteids.....	9.86	1.71
Fat.....	15.04	2.49
Carbohydrates.....	68.85	11.46

Leeds(loc.cit.)has analysed the so-called Lactated Food prepared by Wells & Richardson,but found the alleged fifteen per cent.of diastase absent and that about a third of it was composed of starch,despite the vendors' statement that the latter was not present.He gives the following comparative tabulation:

Wells & Richardson's Lactated Food.	Advertisement.	Leeds' Analysis.
Water.....	not indicated	7.76
Fat.....	"	1.64
Malto-diastase.....	15.00	not found
Cane-sugar.....	25.00	29.64
Soluble carbohydrates....	39.00	39.00
Starch.....	not indicated	36.43
Albuminoids.....	16.25	11.85
Ash.....	1.98	2.61

Mellin's Food has an enormous sale and is one of the several which has to be given with milk.The firm publish the following tables of the mixture prepared in accordance with their recommendation,and of comparative composition of maternal milk:

Table I.

Analysis of a Mixture of Mellin's Food, Water, and Cow's Milk, prepared in Accordance with the Directions, Viz.-

Mellin's Food, 1 tablespoonful, or ½ oz.; Water, 2 oz.; Cow's Milk, 6 oz.; or Mellin's Food, 5.88; Water, 25.53; Cow's Milk, 70.59. Total, 100.00

			Water	Sugar	Nitrogenous matter	Butter	Salts
Mellin's Food 5.88 (Fresenius' Analysis)	Water	.78	.78				
	Sugar	4.27		4.27			
	Nitrogenous matter	.57			.57		
	Salts	.26					.26
Water 25.53	Water	23.53	23.53				
Cow's Milk 70.59	Water	61.03	61.03				
	Sugar	2.68		2.68			
	Butter	2.54				2.54	
	Casein	3.88			3.88		
	Salts	.46					.46
Totals .. 100.00		100.00	84.34	6.95	4.45	2.54	.72

Table II.

Comparative Analysis of Human Milk and Mellin's Food.

	Analyses quoted by Tanner.				Wurtz's Milk.	Leeds' analyses of 43 samples			Mellin's Food as above.
	Human Milk.								
	Fair.	Dark.		Average.	Average.	Minimum.	Maximum.	Average.	
Water...	89.20	85.33	88.90	87.81	87.02	83.84	89.09	86.76	85.34
Sugar...	5.85	7.12	4.36	5.78	7.05	5.40	7.92	6.99	6.95
Butter..	3.55	5.48	2.69	3.90	4.06	2.11	6.89	4.01	2.54
Nitrogenous matter.	1.00	1.62	3.92	2.18	1.67	0.85	4.86	2.05	4.45
Salts...	0.40	0.45	0.13	0.33	0.20	0.13	0.35	0.21	0.72
	100.00	100.00	100.00	100.00	100.00				100.00

Leeds also gives the following analyses of Mellin's Food and a mixture of the same:

	Mellin's Food.	A Mixture.
Soluble carbohydrates.....	68.18	4.11
Proteids.....	10.07	1.89
Fat.....	0.18	1.86
Cellulose, gum, &c.....	5.45	....
Salts.....	3.75	0.43
Total Solids.....	87.63	8.29
Water.....	12.37	91.71

(Mixture composed of Mellin's Food 3 parts; milk 47 parts; water 50 parts.)

Horlick's Malted Milk is a dry powder for addition to water; its comparative analysis is as follows:

	The Company	The "Lancet"	Human milk: all but 4% water removed.
Water.....	3.27	2.21	4.00
Proteids..	22.26	21.85	23.39
Fat.....	6.78	8.40	23.39
Sugar.....	46.63	63.59	46.78
Dextrin...	17.16		0.00
Ash.....	3.90	0.95	2.44

None of these artificial foods are able to take the place of maternal milk,even though the composition of some of them is scientifically arranged;for they do not possess the antiscorbutic element,they are deficient in proteids and fat,and they contain far too much carbohydrate in the form largely of free undigestible starch.They are troublesome to prepare and expensive to the household;their prolonged administration is not entirely free from danger,despite the increase of weight sometimes observed.Monti(loc.cit.)pointed out that the specialities of Nestlé,Ridge,and Mellin are short in fat and proteids;that,though temporarily efficient sometimes,they are in no sense a substitute for maternal milk;that in the first months of life they should not constitute the entire food of the child;and that they are useful dietetic adjuvants after the age of five months and weaning.Cautley(loc.cit.)lays down the axiom that proprietary foods are unnecessary for the proper feeding of infants so long as it is possible to obtain good cow's milk,cream,and sugar;he adds that they should never be used before the sixth month,and then only as diluents.Starr(loc.cit.)holds that they are useful as mechanical attenuants;but that,unless they are prepared with milk,it is questionable whether any of them can permanently meet the infant's nutritional demands.Rotch (loc.cit.)is very emphatic regarding the unreliability and lack of uniformity in the composition of artificial foods,which vary too greatly in their analyses to keep even within the acknowledged varying limits of maternal milk.Smith(loc.cit.)favours their employment only as adjuvants.Bierdert(loc.cit.)recommends the prepared foods,added to the milk mixture,after the sixth month as a good method of beginning the administration of starch.Bendix(loc.cit.)says that their only proper use is in addition to other foods,for short periods of time, and never before three months;he recognises the possibility of scurvy incidence when they are given exclusively for too long a time.Baginsky(loc.cit.)thinks that they may be administered after the third month as an adjuvant to maternal milk;and adds that the experience of all observers shows that the long-continued use of any of them causes a slight dyspepsia.Demme(loc.cit.) has observed a diminution in the number of red corpuscles in children who have received starch in their food too soon.Ashby and Wright(loc.cit.)hold that artificial foods are only of temporary use,during a journey,etc., or when milk will not agree in any form;theydo not readily ferment,but if used for too long a time,especially if the children are more than six months old,both rickets and scurvy are apt to occur.Drews and Krauss(Jahr. f.Kinderh.,Bd.47)have experimented with the food known as Somatose,which they find well digested by healthy as well as poorly developed infants,it producing a finer curd when mixed with cow's milk;it had no odour and its taste was not unpleasant;small doses seemed to increase peristalsis without exciting the secretions of the intestines;it was useful in all digestive disturbances in infants,and was especially valuable in replacing the nitrogenous loss of the organism.Wolf(Allg.Wien.med. Zeit.,1896)speaks well of the same preparation,especially in the dietetics of atrophic children.Still(loc. cit.)lays down the general rule that the suitability of a proprietary preparation is not established by the fact that it is taken well and gives rise to no ill

effects,as it may be many months before such unfavourable and undesirable results as rickets and scurvy are observed.This important point he would have everyone remember in planning the dietary of infants.Keller(Berl. klin.Woch.,Sept.3,1906)similarly warns and dwells on the fact that,though the symptoms may be slow in development,they are apt to serious when once seen.I have observed that children reared on these starchy foods have a very poor capability of resisting disease or of recovering from the same.

Bottle-Feeding.

The administration of the infant's food calls for the exercise of great care,it being otherwise by no means free from danger.The bottle chosen should be such that every part of its inner surface can be reached with a swab or brush;those with sharp angles should never be used,as they cannot be kept clean and the milk is apt to collect and sour in their corners.It is a good plan to have the bottle graduated in such a way that it need only be filled to the amount proper for a given feeding and also allow of the estimation of the amount of food consumed by the child at the meal.The plainer the nipple the better;it should be of black rubber and have not too large a hole.Indeed,it is better to secure one without holes and make a suitable one with a needle.When the bottle is filled with milk and held upside down,the milk should escape drop by drop;if it runs out in a stream,the hole is too large - and then the infant will feed too rapidly and develop dyspepsia,colic and other troubles.Great attention should be given to the care of the bottles and nipples,as a collection of sour milk in a corner will spoil all other milk added.No bottle should be used more than once in the twenty-four hours,so that there should be as many bottles in use as there are feedings during that period.As soon as the child is satisfied,the nipple should be washed inside and out with good soap and hot water,and a needle or bristle should be passed through the hole in order to force out any curd which may have lodged there;then it should be immersed in a fresh saturated solution of boric acid. All the nipples should be boiled for a quarter of an hour daily.After each feeding the bottle should be similarly washed and wiped inside and out,so that a trace of milk or milkiness remains,it then being rinsed thoroughly with freshwater and placed on end to drain.Once in every twenty-four hours all the bottles should be boiled.To prevent breakage they should be filled with cold water and placed in a vessel containing cold water,which is then brought to the boil.After boiling vigorously for a quarter of an hour the vessel should be taken from the fire and allowed to cool until the bottles can be removed without scalding the hand.Cracking may result if an effort be made to cool them by the addition of cold water.The infant about to be fed should be held in a comfortable position,and the bottle in such a way that the nipple will always be full of milk;he should never be put to bed with the nipple in his mouth,and,as in breast feeding,there should be no dawdling allowed over the meal.If a fair trial shows that the infant is not anxious for its food,the bottle should be taken away and not offered again until the next feed is due.If it persistently refuses the food,there is something wrong and in need of immediate rectification.Only the proper

amount of modified milk for one meal should be put into the bottle, and it should then be warmed to body temperature by placing the bottle in a vessel of hot water. In cold weather a piece of flannel may be wrapped around the bottle to keep the milk from growing cold towards the end of the feeding. Usually the child will consume all the milk allowed for the feed; if any be left over, it should be poured down the sink. When the weather is warm, the milk may be sterilised or pasteurised immediately it is received, or, if this cannot be done, it may be placed on ice. The various modifications of the milk may be performed as already described. The amount of food required will vary with the age of the infant, its general health and development, and the condition of its digestive organs. Ashby (loc. cit.) gives the following table of the average amounts from birth to the end of the first year in the case of a healthy infant:

Age.	No. of Feedings.	Amount.	Interval.	Amount in 24 hours.
First week...	10	1 oz.	2 hrs.	10 oz.
2.4 weeks....	10	1½-3 oz.	2 hrs.	15 - 30 oz.
4 wks.-3 mos.	9 - 8	3-4½ oz.	2½ hrs.	22 - 36 oz.
3 mos.-6 mos.	7	4½-5½ oz.	3 hrs.	28 - 38 oz.
6 mos.-9 mos.	6	5½-7 oz.	3 hrs.	33 - 42 oz.
9 mos.-12 mos.	5	7½-9 oz.	3½ hrs.	37 - 45 oz.

When the child comes to the age of six months a little farinaceous material may be added to the diet; but the stools should be watched for undigested food. The best forms of starchy food are whole meal flour, oatmeal- or barley-jelly, thoroughly cooked and of such a consistence that the food will pass readily through the nipple. Should the digestion not be satisfactory, a little extract of malt should be added to the food after it is boiled and a few minutes before the meal is due. After the age of eight months a little thin chicken or mutton broth, from which the fat has been removed, may be added to the food.

Diet during the Second Year.

After the age of twelve months the child being a mixed feeder, it is not quite so difficult to arrange the food, though the exercise of caution is still required. The digestion is capable of dealing with starchy food, and there need not now be so much fear of the patent foods or other sugary preparations. Milk should, however, form the basis of the diet. Freeman (Arch. Ped., Vol. xxi, p. 403) thinks that too great a variety of food is given during the second year and too little milk - this being undoubtedly a frequent source of danger, as when once the mother is allowed more latitude in dietetics, she is tempted to give the child too many feeds of patent and other foods, thereby increasing the amount of starchy materials at the expense of the milk. Mothers should be warned against allowing the child sweetmeats at this age, lest the appetite be spoilt and an actual repugnance to wholesome food be created. The child should be fed according to indications, and not with anything that is going from the general table. The fact that the child is being properly fed will be indicated by the healthiness of its complexion, cleanliness of its tongue, and the normal condition of the stools. Gruel, plain or mixed with milk, makes a convenient means of supply starchy material; it may be made of barley or oatmeal if constipation is present. Cane-sugar or salt will render it more palatable.

There should be four or five meals in the day, taken at intervals of four hours; they may be given with the spoon, the bottle being discarded. Milk, barley, oatmeal, wheat flour, farina or arrowroot gruel, barley or oatmeal jelly, light-boiled egg with or without stale bread crumbs, beef or mutton or chicken broth, chicken jelly, beef-juice or the juice of various fresh fruits may be allowed at this period. The first meal should be taken at about 7.30 a.m., or as soon as the child wakes up in the morning. It may consist of a small slice of stale bread, crumbled finely, in a cup of new or modified milk. The second meal may be taken at 11 a.m., and should consist of a drink of milk and a thin slice of bread and butter. For the third meal, at about 1.30 p.m., there may be allowed a cupful of beef-tea with a little toast, bread crumbs and gravy, a lightly boiled egg with bread and butter, and a little well-cooked rice or sago pudding. Veal, mutton or chicken broth may also be given according to preference. The fourth meal may be given at 6 p.m., and may comprise a cupful of milk and barley gruel or plain bread and milk. The fifth and last meal, if necessary, should be at 10 or 11 p.m., and should consist of a cupful of milk. After the age of eighteen months the first meal should also be at 7.30 a.m., and consist of a cupful (eight ounces) of new milk, a lightly-boiled egg, a thin slice of bread and butter, or porridge and milk with or without a little treacle. The second meal may be at 11 a.m., and comprise a cupful of milk. The third meal should be at 1.30 p.m., and include a little fish from which all the bones have been carefully removed, boiled and broken up into small pieces, or a little boiled fowl, minced, and a little mashed potato, with gravy, rice or tapioca or sago pudding, with a little stewed fruit or preserve. The fourth meal may be at 6 p.m., and consist of a cupful of milk with some bread and butter.

Diet after the Second Year.

The diet of the child should now be of a much more liberal character; it should be of as varied a kind as possible to prevent the occurrence of dislike for any particular kind of food. The breakfast should consist of mainly porridge and milk, or of bread and milk. A little bacon or lightly-boiled egg may sometimes be allowed. For dinner the meat should be cut up into small pieces or minced, and the child ought to be taught how to thoroughly masticate it. Soups, made with meat and vegetables, may be administered. Plain farinaceous puddings, with stewed fruit, are preferable to pastry, which should not be allowed. The best drink is milk or milk and water. It is very necessary to avoid indiscriminate and irregular feeding. Holt (loc. cit.) says that the following articles should not be given to children under four years of age, and that, with few exceptions, they should not be allowed before the seventh year of the child's existence: Meats.- Ham, sausage, pork in all forms, salted fish, corned beef, goose, game, kidney, liver, bacon, meat-stews, and dressing from roasted meats. Vegetables.- Fried vegetables of all kinds, cabbage, potatoes, - except when boiled or roasted, - raw or fried onions, raw celery, radishes, lettuce, cucumbers, tomatoes, - raw or cooked, obeets, egg-plant, and green corn. Bread and Cake.- All hot bread and rolls, buckwheat and all other griddle-cakes, all sweet cakes, particularly those containing dried fruits and those heavily frosted. Desserts.- All nuts, candies, pies, tarts, and pastry of every description, also salads, jellies, syrups, and preserves. Drinks.- Tea, coffee, wine, beer, and cider. Fruits.- All

dried,canned,and preserved fruits,bananas,all fruits out of season and stale fruits,particularly in summer.Some such fixed hours of meals as those above given should be arranged and strictly adhered to,feeding between meals being very objectionable.If the child be hungry during the intervals,the mealtimes should be approximated,though in certain cases a little milk and biscuit will do no harm.The sweet-craving in children is almost as bad as the alcohol-craving in adults,and all possible should be done to put it down.Freeman(Arch.Ped.,June,1904) tabulates the diet after the third year and thereafter as follows:

Diet of the Third Year.

6 A.M.	10 A.M.	1 P.M.	5.30 P.M.
Orange-juice, 10 oz.milk, 6 oz.gruel, Soft-boiled egg, Bread and butter.	8 oz.milk.	6 oz.soup, Meat, Bread and butter, Vegetables, Dessert.	10 oz.milk, 6 oz.gruel, Bread and butter.

Diet after the Third Year.

Breakfast.	Dinner,12-1 P.M.	Supper, 6 P. M.
Fruit, Cereal, Milk, Bread and butter, 1 or 2 eggs.	Soup, Meat, Bread and butter, Vegetables, Dessert.	Cereal, Milk, Bread and butter.

Cautley(loc.cit.)arranges the diet of the child from the eighteenth to the thirtieth month according to the following tabulation:

FIRST MEAL at 6.30 to 7.30 A. M.

A large cupful of milk with rusk,stale bread or milk biscuit broken up and soaked in it,or some bread and butter.

SECOND MEAL at 8.30 to 9.30 A. M.,one of the following:

A Basin of bread and milk.
Oatmeal porridge with milk,cream,or golden syrup.
A basin of hominy grits and milk.
Boiled milk or cocoa with bread and butter.
Boiled milk,a lightly-boiled egg and bread and butter.

THIRD MEAL at 1.0 P. M.

F i r s t C o u r s e: One of the following:

Mutton,undercooked beef,chicken,turkey,or fish, minced finely;pounded up for the younger children in a mortar into a paste.One tablespoonful of one of these mixed with mashed old potato or stale bread crumb and gravy.
Lightly-boiled or poached egg with mashed potato or stale bread crumb and gravy.
A large cupful of broth,soup,or beef tea,with mashed potato or stale bread crumb.

S e c o n d C o u r s e: One of the following:

Custard or plain milk pudding;blancmange;cornflour or ground rice mould; plain sweetened jellies.

FOURTH MEAL at 5.0 P. M.

A large cupful of milk,with bread and butter,rusks, milk biscuits,or sponge fingers.
A cup of thin cocoa,made with milk,and bread and butter.
A small basin of milk gruel or bread and milk.

FIFTH MEAL ay 9 P. M.,if the child wakes for it:

A cup of boiled milk,and a biscuit or piece of bread soaked in it;or a cupful of milk gruel.

The same author gives the following tabulation of the dietary after the age of two and a half years:

BREAKFAST at 7.30 to 8.30 A. M.:
Either bread and milk, porridge with milk or golden syrup, or hominy grits and milk; bread and butter, dripping, or fruit jelly; milk or cocoa to drink.

After the Age of Four:
Eggs lightly boiled, poached, or scrambled; plain omelette, a little fat bacon or ham, a little fish or fresh potted meat may be added to the diet.

LUNCH at 11 A. M.:
A cupful of milk or broth and a slice of bread and butter, or a plain biscuit.

DINNER at 1 P. M., of two courses, slected from:
Minced beef, mutton, chicken, or turkey; boiled fish; poached egg; mashed potatos and pounded-up vegetables; macaroni; milk puddings, blancmanges, farinaceous moulds, stewed fruits, jellies.

TEA at 5 P. M.:
A basin of bread and milk, milk gruel, hominy and milk; a cup of milk with bread and butter, biscuit, or bread and potted meat or fish; fruit jellies may also be allowed.

SUPPER at 9 P. M., if required:
A cup of milk and a biscuit.

One or other elements of the dietary may in the case of rickets be enhanced by some such article as the white of egg or raw meat-juice, which latter contains about five per cent. of proteids, is very rich in albumin, and has antiscorbutic properties. A few drops or more may be added to the milk according to indications. Plasmon, Somatose, Casumen, etc., act in pretty much the same way; but peptonoids are more stimulants than foods, as they usually contain about twenty-three per cent. of alcohol. The older the child the more should meat enter into the diet, though the so-called erethic rachitic cases, seen in thin children, according to Jacobi, need less meat and more farinaceous foods than others. Cream makes an ideal form of fat for administration in rickets, though some of the cases have difficulty in digesting it - in which case the yolk of egg may be substituted. Stern (Arch. Ped., Vol. xxii, 1905, p. 441) expects the best results from the yolk of egg when it entirely replaces the milk fat, one ounce of the former, according to him, be equal to the same amount of cream in fat. Virol is of service in the dietetics of rickets, it containing the yolk of egg, extract of malt, lemon-juice, and a fifth of its volume of bone-marrow. I have had a large experience of its exhibition, and have usually derived satisfactory results therefrom, though some of the cases have not tolerated it well and objected to the taste. Burney (Med. Times & Gaz., Dec. 10, 1904) thinks that it is not infrequently retained when cod-liver oil is rejected; he described six cases of rickets, in age from nine to seventeen months, which did well on Virol; and he sees no objection to giving it to very young infants. To his mind it has the following advantages: First, it can be given when cod-liver oil is vomited; second, it may be exhibibited even during the hot months of the year; third, it never causes a distaste for food; fourth, it is palatable; and fifth, it is a reliable preparation. Leaky and Ramsden (Ibid., Aug. 11, 1906) have given as much as two and a half ounces of Virol every day for three months without any unpleasant results, though this experience is at variance with that of other observers.

It is best given in gruel,which it partially dextrinises; but older children may take it from the spoon or have it on bread and butter.Hutchinson(Patent Foods and Patent Medicines,p.19)thinks that Virol is no better than toffee or chocolate as regards food-value,it containing,he finds, about twenty per cent.of fat and sixty per cent.of carbo-hydrate.Cod-liver oil is most useful in rickety cases,its beneficial effects being due,according to Gautier and Morgue(Twenth.Cent.Prac.,p.558),to,first,the easy assim-ilation of its fatty material;second,its richness in phosphates,phosphoglyceric acid,lecithin,and phosphorus in organic combination;and,third,the presence of small quantities of bromine and iodine.Great care should be taken to moderate the doses of this agent.Cheadle(loc. cit.)holds that cream is quite as efficacious as cod-liver oil;and he warns against saturating the rachitic child with the latter and chemical food without properly adjusting the fat in the food.Hutchinson(loc.cit.)thinks that ordinary cream and butter act just as well as cod-l-iver oil emulsion in most cases.Olive oil,salad oil and lipanin have also been recommended as substitutes for cod-liver oil;and a cheap agent of this class is Malto-livine,which is a combination of olive oil and extract of malt.Fucol is sometimes administered on the same gr-ounds.

HYGIENIC TREATMENT.

The importance of fresh air,sunlight,warmth,proper clothing,rest,exercise,baths,and so forth in rickets cannot be denied.Were certain unfavourable conditions of this kind fulfilled,most likely rickets would ere long be wiped out - this proviso particularly applying to clean wholesome dwellings,proper clothing,and breast-feeding of infants,a physiological function which so many present-day mothers are unable or unwilling to undertake.Fresh air is of prime importance;during the clement months of the year the child should be taken out into it as soon as it is a week old,at first in the nurse's arms and later in its parambulator.In cold or wet weather the fresh-air treatment should take the form of being carried into another room,which has previously been well warmed and ventilated.The nursery should have a southern aspect,if possible,and the windows should be freely opened.In the winter,when it seems unwise to have the windows wide-open,it is a good plan to have a board fitting under the bottom sash,so that a free current of air may enter the room between the upper ones and secure an upward direction.Though fresh air is so important, great care should be taken to avoid draughts.The temper-ature of the nursery should be about 60.F.,and it should be a large and sunny apartment with a fireplace.Electric light is best for the nursery,as it consumes no air and gives off no products of combustion;gas an gas stoves are to be condemned on these grounds,and candles and lamps are equally objectionable.Removal from a damp,cold place to a dry and warmer climate,or to the seaside,is beneficial;and the effect of light and sunshine there and elsewhere is striking sometimes.As long a time as possible should be spent in a marine climate,so that the full benefit of the ozone may be secured.So long ago as 1750,R. Russell pointed out the supreme advantages of sea air,Margate being perhaps the first place to attain popularity for this reason.Gastrointestinal cases seem to do very well at the seaside,but the bronchitic or

respiratory ones should have a mountain climate instead. Sunlight has a marked antirachitic action, as may be instances by the rarity of the disease in the tropics and its comparative prevalence in countries where the contrary conditions obtain. The infant should have a proper amount of sleep, for the first two or three days of its existence most of its time being spent in this way; for several weeks it should not ordinarily be awake for more than two or three hours during the twenty-four, up to six months from eighteen to sixteen hours of sleep being desirable. Sleep should not be induced by such things as comforters or soothers, for theyare apt to be dirty and a source of gastrointestinal infection. Rocking the cradle is not always the good thing it seems, for it tends sometimes to churn up the contents of the stomach and produce various digestive ailments. The clothing of the infant requires also careful attention. Long clothes are unobjectionable seldom, as they are heavy and confine the limbs. Shortening of these should take place after the first few weeks, but should not be carried to excess. The lower limbs should not be exposed for the purpose of hardening, which is often injurious, but so covered that, while protected from the inclemency of the weather, the legs have unfestricted movement. In rickets the general circulation is depressed, and the child not infrequently suffers from cyanosis of the limbs and coldness of the feet; the perspirations also contribute to the coldness of the surface. The underclothing should be of soft woollen material, and the limbs and neck should be properly covered. A flannel nightdress is advisable, as the child throws off its bedclothes; and a flannel binder should cover the abdominal wall, atonic conditions of which it tends to correct. It supports what is usually in these cases a weakly part, it stimulates the respiratory functions, and it is not without effect on the sluggish abdominal circulation. Some writers advise that the belt be worn continuously and be made of elastic, so as to act as a perpetual massage; whereas others advise only its intermittent use for an hour or two each day The napkins of the child should not be applied too tightly, and as soon as they are soiled they ought to be changed. Every morning ~~the child should be bathed, at night he should be sponged with tepid water~~ the child should receive a bath, using warm water and soap, and at night he should be sponged with tepid water, the temperature being about 90.F. at first, and never lower than 60.F. Afterwards he should be well rubbed and dried. Rickety children are very susceptible to cold, and this fact should be borne in mind. Salt water baths are often of service, and good results have been claimed from one of sand. Careful massage is of use, as a rule, if there is not much softening and tenderness of the bones. Every morning, after the bath, the child should be laid on his face and be shampooed with the open hand along the spine, perhaps with a little warm olive oil, for ten minutes or so; this may be repeated at night. Massage of the abdomen is usually very beneficial, as it stimulates the muscular wall of the cavity and also the muscles of the intestines, and thus relieves meteorism or constipation; it is also not without effect on any congestive conditions present, and the respiratory function can be stimulated in this way. A mild current of electricity has been recommended for the treatment of these rachitic

cases,one of the strongest advocates being Tedeschi,who, in 1882,spoke highly of its use.He advises the continuous current and the electric bath;and he claims to have benefited perspiration,insomnia,muscular pains,and laryngismus in this way.Ewart applies electricity in rickets also,he being first led to do so by observing the benefi-ts of the sinusoidal current in the cardio-abdominal atony of failing compensation.He uses it as a bath - general or foot.The X-rays have been vaunted in America for the relief of rickets,where Cleaves found them of great service in hydrocephalic cases.Phototherapeutic treatment has also been advised,particularly sun baths.

The prevention of deformities should be attempted in every case;careful handling of the child is important, especially if the case be severe,lest fractures or twfst-ings occur.The very young infant should be carried about on a cushion.The child should never be allowed on his legs too soon;but if the child is of an age when he is very desirous of walking,he should have applied a light padded splint extending well below the feet,by which means progression will be prevented.

DRUG TREATMENT.

Quite a host of drug have been from time to time advised for the treatment of the rachitic dyscrasia,but only a few of the better-known need here be described.

Cod-liver Oil.

This is both a food and a medicine,which,"though employed",remarks Trousseau(loc.cit.)"from time immemorial by the people in England,in Holland,in Westphalia, and on the northern coasts of Germany,was never,till recently,prescribed by scientific practitioners.At the commencement of this century(the nineteenth),two physicians on the other side of the Rhine,Schenck and Fehr, published some very interesting observations on relation to its use;but the facts to which I refer remained unknown in France,till 1827,when Bretonneau,who,like everybody else,was ignorant of them,was led,in the manner I am now going to relate,to try cod-liver oil in rickets.AT that date,there was a Dutch family at Tours, under the medical care of the eminent practitioner.One of the children,fifteen months old,became rachitic in an extreme degree.For four or five months,Bretonneau fruitlessly contended with the malady,exhausting the entire series of medications then recommended,when the child's father told him that his eldest son had been cured,in Holland,of the same malady by fish-oil,a popular remedy.Bretonneau advised the same medicine to be given to his young patient;the success was so incredibly rapid that my ullustrious master was quite struck by it.Encouraged by the result in this first trial,he repeated the experiment on other rachitic subjects;and it was when thus occupied with researches into the action of cod-liver oil,of the good effects of which he had satisfied himself,that he had the pleasure of finding that similar good results had already been obtained by the German physicians whose names I have just mentioned.Bretonneau informed Dr.Guersant,Professor Jules Cloquet,and me of his curious observations;and then we,in our own turn,administered the remedy to the rachitic children we had to treat.The results were as completely satisfactory as those of which we had been informed.The use of cod-liver oil soon became general;and at the present day there is not a physician who has not had recourse to it under

similar circumstances."The fat which it contains entitles it to be regarded as a food,and certain animal extracts cause it to be regarded also as a drug.The tendency in the past,however,has been to give it in too large doses far beyond the infant's powers of assimilation;and it is,moreover,not infrequently prescribed when the child is too feeble to derive benefit from its exhibition.Further,the oil does not appear to be tolerated so well as in tuberculous affections.The author above quoted was of the opinion that ray oil,herring oil,the fish oil of commerce,or even the oil used by cobblers,were of equal value with cod-liver oil;and he though that the crude form of the latter was preferable to the refined preparations."The more impure and rancid",he insists,"the animal oils are,the more perfectly are they assimilated, the more does the digestive canal become accustomed to digest them".He adds that"in northern countries,on the shores of the Baltic Sea,where it is a common practice with the people to give to weak children and valetudinarian adults whale oil and fish oil indifferently,you may be sure that much care is not bestowed on the purification".There seems to be a prejudice amongst some persons,as in the case of castor oil,in favour of the brown and unpurified cod-liver oil.It may be,as Jacobi(loc.cit.) remarks,"that the mystery of its action is best explained by attributing to it a percentage,though ever so slight,of some organic tissue-juice of a nature and efficacy to be compared with that of the ductless glands";and it is possible that the modern elaborate process of refining removes some such constituent.Most observers,despite Jacobi's denial,are agreed that it is the fat which is the essential factor,and that any other oil,such as olive oil or cottonseed oil,may be used with equal success in those cases where marked repugnance to cod-liver oil is manifested.In short,it is not the form of the fat which is the vital factor,but its digestibility.Emulsions of the oil,though certainly more palatable,are,on the whole,inferior in their effects to that of the plain oil.In the case of infants it is advisable to commence, say at six months,with doses of ten minims of the oil, two or three times a day,after meals.Even at two years of age,not more than a teaspoonful should be administered at a time when the exhibition is first commenced. Larger doses are not only useless,but even hurtful to the gastrointestinal canal.It should never be given when digestive troubles are present,the tendency being in some places to drench the child with the oil and chemical food irrespective of such factors as these.A single dose at bedtime sometimes acts better than several doses during the day.The addition of ether or alcohol sometimes renders it more tolerable and less likely to occasion unpleasant eructations.It may be better borne when prescribed as an emulsion - either a good proprietary brand or better one freshly made with yolk of egg and brandy.It may have added to it,in such cases as cod-liver oil is not well tolerated,extract of malt. It is sometimes given with the hypophosphites of sodium, magnesium and calcium;also with quinine,iron,creosote or free phosphorus.The rachitic mixture of the Edinburgh Children's Hospital is a useful preparation,each drachm containing eighteen minims each of cod-liver oil,syrup of the hypophosphite of calcium and lime-water;a grain of the hypophosphite of calcium,eight minims of mucilage;

and a ninth of a minim of oil of cassia.The oil may,if necessary as in feeble cases,be smeared on a binder and applied directly to the abdomen,which latter may also be regularly massaged with it;its presence in the stools proves that a certain amount of absorption takes place through the skin.Soles(Arch.de Gin.Obst.y Ped.,1903,Vol. xvi,No.18,p.401)speaks highly of creosote in combination with cod-liver oil,the fermentation of which it obviates inthe digestive tract and aids the nutrition of the tissues in rachitic cases;it is also not without remedial action on the chronic gastrointestinal catarrhs not infrequently present.He always exhibits the tannate of creosote or guaiacol when there is obstinate diarrhoea,with or without the oil or pepsin or the glycerophosphates.Hutchinson(loc.cit.)holds that malt extracts are not nearly so beneficial as ordinarily supposed,and remarks that,unless the diastatic action is indicated, honey acts just as well and costs as few pence as compared with as manyshillings.

Phosphorus and Its Preparations.

Phosphorus was introduced into the therapy of rickets by Trousseau,who exhibited it in the form of phosphorated butter.Hahnemann and Kassowitz advocated its efficacy also,the latter regarding it as almost a specific,especially in cases marked by craniotabes which he found it to cure,it assisting also the closure of the anterior fontanelle and warding off threatening laryngismus.Jacobi(loc.cit.)also has great faith in the drug in craniotabic cases and severe rachitic attacks marked by inflammation of the epiphyses,debilitation,gastrointestinal catarrh,and scorbutic signs.Phosphorus secured popularity in the treatment of this disease because it tended to accelerate the healing of fractured bone, as was experimentally proved by Wegner,who broke the bones of animalsand subjected them to the action of the drug in small doses.Coneetti also claimed for phosphorusa specific action.It is largely prescribed abroad;but by many in this country it is though that much of its efficacy is due to the cod-liver oil with which it is so often prescribed.There is,however,a certain amount of risk contingent to its exhibition,cases having been from time to time recorded in which the child has developed icterus and died from the effects of phosphorus poisoning,as verified on post-mortem examination.Opinion seems divided on the question of its action;but it seems agreed that it should be administered with great care.My own idea is that it is perhaps better to use means which are less free from danger.Its use should be reserved for severe or intractable cases;and it should never be prescribed when gastrointestinal troubles are present.The dose should be a very small one,viz.,from 1/600 to 1/200 of a grain three times a day.It may be administered in any flavoured oil.Holt(loc.cit.)has exhibited phosphorus in rickets for many years,and thinks that,except perhaps in early craniotabic or hervous cases,it is of little or no use.Cheadle(loc.cit.)never uses it,as he can always effect the maximum possible benefit from other remedial agents.Henoch,Monti,and Heubner also disapprove of it.Fedele(Riv.d.Clin.Ped.,Jan.14,1904)describes a small series of cases in which the drug acted well,presumably by neutralising the toxic products of the intestinal canal responsible for the origination of rickets by infecting the osseous and hervous systems.He gave 1/200 of

a grain, and after thirty days of this treatment observed a marked improvement in calcification, eruption of the teeth, and walking, with commensurate improvement in the laryngismus, hyperaesthesia and other troubles. Concetti (Allg. Wien. med. Zeit., Jan. 27, 1903) cautions against carelessness in the preparation of the drug in this disease; and he says that it must be thoroughly mixed with the oily vehicle so that there may be uniformity in the dose. He dwells on the great importance of well shaking the bottle: otherwise the last doses will contain too much of the drug and give rise to symptoms of poisoning or even death. His method of preparing it is to dissolve the phosphorus in ether and then in oil of almonds, with vigorous agitation, after which the whole is incorporated with cod-liver oil and placed on a water-bath for some time to get rid of the ether. The mixture is hermetically bottled and directions displayed for thorough shaking before administration. The proportions being one cubic centimetre of phosphorus to one hundred grammes of cod-liver oil, the dose of the mixture is a teaspoonful, which contains one-twentieth of a centigramme, night and morning. He differs from his critics in denying that the benefits observed are due to such factors as hygiene, as he has secured some of his best results in dispensary practice where they are admittedly bad; according to him, the therapeutic efficacy of the drug is beyond dispute. In opposition to this we may advance the observations of Nathan, who treated four hundred and seventy-seven rachitic cases during a period of one month - one hundred and fifty with phosphorus, fifty with cod-liver oil, one hundred and fifty with calcium phosphate and common salt, and one hundred and twenty-seven with modified milk. Those in receipt of the latter did best, and those treated with phosphorus made comparatively no progress towards recovery. Nebelthau regards phosphorus as a deadly drug in rickets, as one of his cases died within three days of commencing the drug in three-milligramme doses. Leo also reports fatal toxic cases, and regards the drug as worse than useless. Ungar, however, thinks that the fatalities were due to other factors than phosphorus, which he regards as very beneficial, especially in the presence of laryngismus; he gives daily doses of 1/120 of a grain dissolved in olive or almond oil. Various compounds of phosphorus have found favour of late, such as the syrup of the hypophosphites, the glycerophosphates, and lecithin. The well-known syrup. ferri phos. co. is useful, in doses of a half to one drachm, with or without cod-liver oil, in anaemic and other cases. The glycerophosphates are of great service in rickets complicated with anaemia, neurasthenia, and general malnutrition. The basic glycerophosphoric acid forms both acid and neutral salts, the acid preparations being reserved for oral administration and the neutral for hypodermy; the former preparations are soluble in water, amorphous, and very stable; they take up water readily. These preparations are productive of improvement in tissue nutrition, and have the advantage over other phosphorus compounds in that they are stable and easy of assimilation. Protylin abd Fersan are phosphorus preparations containing albumin. They have been much recommended by Bilgorajski (Wien. klin. Rund., 1904, Nos. 11, 12), who finds that the former is very well borne in rickets and effective in bone disease. He conbines it with iron, bromides, etc., according to indications. Organic phosphorus preparations have been made from animal and

vegetable matter, Phytin is an example. It is made from the seeds of plants, and is said to contain nearly twenty-three per cent. of phosphorus in an assimilable and non-poisonous form. The Basle Society of Chemical Industry, whose speciality it is, inform us that it is "an acid calcium and magnesium double salt of the new phosphorus principle discovered in plants, which is stored up as a phosphorus reserve in all seeds, tubers, and rhizomes." On theoretical grounds at least, we may regard it as readily assimilable and likely to promote the general metabolism of the organism. Lecithin is weaker in phosphorus, containing only about four per cent. of it; it has no tissue-building of calcification-promiting elements, is expensive, and not to be recommended for routine administration. But Gilbert and others make the opposite claims and advise its trial. Another preparation of this class is Fortossan, which is inexpensive and beneficial in rachitic cases. It is a neutral soluble compound of Phytin, and is said to improve the general nutrition and growth of the patient. It is soluble and may be given in milk or other food.

Ferruginous Preparations.

Iron is of great value in the treatment of the anaemia of rickets, on account of its well-known action on the blood-cells and haemoglobin, and the muscular and general debilitation are also relieved by it. The syrupy preparations are apt to cause acidity in these cases, so that the wine, the perchloride, or the ammonio-citrate should be used instead. The last-mentioned may be prescribed with aromatic spirits of ammonia, spirits of chloroform, glycerine and infusion of calumba. In this the sal-volatile acts asa stimulant, as does the alcohol in the wine of iron. Another useful combination is the phosphate of soda, tartrate of iron and glycerine; and there is also much to be said for the citrate of iron and quinine in mixture with glycerine and water. The condition of the stomach must be watched during the administration of iron, but even in such cases the peptonate of iron, alone or in combination with other indicated drugs, acts well. The syrup of the iodide is a popular remedy in rickets; it should be given in small, gradually increasing doses after meals. Cheadle, however, does not advise the iodide of iron in rickets, as it has been known to produce purpura and greatly weaken the patient. Thyroid extract has been recommended in combination with the saccharated carbonate of iron, especially in cases with much anaemia and enlargement of the spleen. Carpenter (Brit. Jour. Chil. Dis., Vol. i, 351) favours the administration of Iron Vitellin or Oviferrin, which is an organic preparation of marked benefit in anaemic cases. He found it to cause an increase of the haemoglobin from fifty to eighty per cent. during a month's trial in one of his patients. Chalybeate waters are said to be of service, such as those of Tunbridge Wells.

Arsenic.

This is another general tonic which improves the condition of the nervous and glandular systems. Starr (Diseases of the Digestive Organs) favours its exhibition in severe vomiting and gastriccatarrh, small doses of the officinal solution being used. Children tolerate it perhaps better than adults, but one must ever be on the watch for toxic phenomena. Levico water contains arsenic and is said to ameliorate the rachitic condition.

Quinine.

This is a useful tonic and may be given as the ironand ammonium citrate,the tannate,the pure drug,or other form.Children readily take it in milk.

Strychnine.

This maybe given in tonic doses of a minim of the officinal solution of the hydrochlorate or sulphate; tincture of nux vomica is also used.It may be combined with the glycerophosphates for the stimulation of the general nutrition and metabolism.

Massage and Electricity.

These have already been considered.

Organotherapy.

Ausset and others have recommended the administration in rickets of an extract of the thyroid gland, as extirpation of this structure in the mother has been said to precede congenital rickets.Though rich in phosphates,there are numerous writers who deny its efficacy in this disease.Stoeltzner(Jahr.f.Kinderh.,1900,Bd.1) holds that suprarenal extract favourably influences the general condition of the rachitic child,diminishing also the liability to neuroses and the sweating of the head; the patients are said to rapidly acquire the power of walking and to exhibit arrest of the bone-softening process.Results with the exhibition of the thymus gland have,as with other animal extracts,been somewhat diverse. Mendel claims to have been successful with it,and holds that this gland favourably influences the development of the osseous structures.

Conclusions.

In general,there is no drug treatment,with the exception of cod-liver oil,iron and other approved tonics and stimulants,which is of much use in rickets, despite the numerous specifics,so-called,from time to time more or less enthusiastically advised.It is,as already noted,hygienic and dietetic management that counts.As Jacobi puts it, "it is air,air,and again air!" that we must have.

TREATMENT OF SPECIAL SYMPTOMS OR COMPLICATIONS.

Much good can sometimes be done by intelligent efforts directed towards the correction of special symptoms or complications as they arise,the extreme tendency to catarrh of mucous membranes in rickets calling for the greatest possible watchfulness on the part of the medical attendant.Uncomplicated rickets is,as we have seen,largely a question of hygiene and dietetics;but disease with catarrh and other troubles opens up quite a new therapeutic field.

Gastrointestinal Canal.

From the very first this requires careful investigation and management,the digestive troubles or catarrhal prodromata being perhaps the inauguration of the disease.On this account the mother is led to bring the child for treatment;she may have noticed no marked rachitic symptoms,-indeed,they may be so slight as to escape even the most vigilant eye,-but she observe the child's restlessness,its occasional vomiting maybe,and the alternating diarrhoea or constipation.Then only does she become alarmed and advice is sought.These patients, not infrequently artificially fed,are apt to suffer from anomalies of the mouth,the hygiene of which cavity must receive due attention.It should frequently be carefully

cleaned with a piece of lint dipped in hot water after each feed;and where any aphthous conditions exist,they should be painted with glycerine of boracic acid or a solution of chlorate of potash,borax,compound tragacanth powder,glycerine and chloroform-water.When the tender, spongy gums indicate the presence of some scorbutic tendency,the patient should be prescribed a mouth-wash of glycerine of carbolic acid,tannic and boracic acid in water,for use three times a day.In this andall other cases the diet and general condition should be supervised.Constipation is apt to be troublesome in this disease, and largely due to the flabby condition and weakened state of the muscular coat of the intestines and the abdominal wall.It is a mistake to prescribe purgatives as a routine measure in this affection;small doses of grey powder are,however,of value,as they are both laxative and antiseptic.Cod-liver oil tends also to correct the anomaly;and a teapsoonful three times a day of a mixture containing magnesia,syrup of ginger,dill-water, and mucilage is of service.Faecal accumulations in the large gut may be cleared out by daily enemata of tepid water,and glycerine suppositories or injections act in the same way.A simple plan in the case of young children is to make a small torpedo-like mass with Castile soap and introduce this into the rectum;if sufficiently thin, it usually causes no inconvenience during introduction, and the results are in the vast majority of instances most satisfactory.The diet must,of course,be carefully arranged on the lines already laid down,and,in the case of children who can tolerate it,oatmeal porridge does good."Rickety children",remark Maunsell and Evanson,"sometimes show a remarkable fondness for common salt,which should be indulged to a reasonable extent.This reminds us of having omitted,in speaking of the food of children, to dwell on the necessity and advantage of giving a suff-icient supply of this condiment.Sufficient salt should always be put into the broths,and given with the animal foods allowed to children,as it contributes to the healthy performance of digestion,and is also a powerful preventive of intestinal worms."Though regarded by some as contraindicated in view of the frequent association of convulsions with rickets,small doses of nux vomica not infrequently improve the general abdominal muscular tone. They may be combined with syrup of senna and compound infusion of gentian and given before meals.The tone of the faulty muscular structures may sometimes be markedly improved by gentle friction and abdominal massage.Teaspoonful doses of extract of male and bone-marrow may here be preferable to cod-liver oil,the stools manifesting less tendency to acid fermentation and having a softer consistency than they otherwise would.The exhibition of the syrup of the iodide of iron,in very small doses and in conjunction with meat extracts,is advised by Jacobi.Castor oil should be given in a single large dose, if a speedy action be desired;otherwise it should be prescribed in small fractional doses several times a day;the addition of salol,salicylate of soda,boracic acid or resorcin will usually markedly enhance its beneficial effects.A tenth to a sixth of a grain of calomel acts ~~acts~~ well.Mineral acids and cascara are useful in certain cases,and flatulence requires the usual aromatic drugs.Diarrhoea may alternate with constiption,and in weak children is apt to be of serious import.The patient is apt to be restless,to have thirst,flatulence,stomatit-is,abdominal distension,and occasional vomiting.The

Bowels are moved frequently,the stools being green or yellow in colour,containing undigested dietetic material, or yellow and frothy.If the condition be severe,all milk must be stopped and albumin- or barley-water administered until improvement is observed.Half a teaspoonful or so of castor oil,according to age,should be given at first, or a sixth of a grain of calomel may act better.When the oil or other aperient has acted to satisfaction,the child should be prescribed a mixture of carbonate of magnesia with lime-water,a teaspoonful of this being given every three or four hours.This simple mixture,of which the components are arranged in equal parts,sometimes acts well even when failure has occurred with such intestinal antiseptics as salol or bismuth subnitrate.When the stools are yellow and frothy and possessed of a sour odour,the patient should be given a teaspoonful,every three or four hours of a mixture containing two grains of the carbonate of bismuth,two minims of the tincture of catechu,four mimims of the compound tincture of cardamoms,a minim of spirits of chloroform,a sufficiency of mucilage of tragacanth,and caraway-water to one drachm.In obstinate cases the patient may improve on Ashby's mixture, which contains salicylate of soda(gr.i),castor oil(m.xv), acacia powder(gr.v),syrup of ginger(m.v),and peppermint-water(ad 3i),a teaspoonful being given every two hours. The same author also prescribes,according to indications, a teaspoonful every four hours of a mixture containing bicarbonate of soda,compound tincture of rhubarb and tincture of ginger(equal two minim parts),tincture of opium(m.ss),compound tincture of cardamoms(m.iii),spirits of ether(m.ii),and cinnamon-water(ad 3i).In certain cases, in the same doses at the same intervals,but in water,a mixture of extract of logwood(gr.iiss),tincture of catechu(m.v),syrup of tolu(m.x),and cinnamon-water(ad 3i).I have sometimes prescribed opium in these cases,but with great care as regards the prevention of its well-known toxic effects.The lactic acid treatment,as already outlines in connection with Metchnikoff's milk,may sometimes do good.Naphthalin is a recognised antiseptic and very soon does away with the bad odour of the motions and urine.Angel Money is a warm advocate of its exhibition in this disease,which he regards as the great slime-producer in connection with the gastrointestinal and urinary tracts.He gives it in cachets,two grains for every year of the patient's age,three times a day.It may,however, be administered in mixture,the unpleasant taste being hidden by oil of bergamot or infusion of chamomile or white sugar.Burney Yeo is in favour of chlorine gas,but it seems to me that children would resent it well-known unpalatability. Urotropin is an intestinal and urinary antiseptic which is sometimes strongly indicated in rickets,though any of the other antiseptics may be tried, especially guaiacol,creosote or creosotal,if vomiting be present.Vomiting and flatulence are very common in infants who are artificially fed,though these nourished at the breast do not invariably escape.In the latter case it is advisable to give a teaspoonful of lime-water before the feed,and to allow only a small amount of milk at each meal.If the infant is being brought up on the bottle and the vomiting is at all severe,condensed or peptonised milk should be substituted temporarily for the product of the cow.In some cases good results are derived from small doses of calomel or of a mixture of equal parts of fluid magnesia and lime-water.The secretion

of gastric juice may be promited by small doses of common salt or of ammonium chloride,the latter appearing to have a marked general beneficial effects in rickety cases.Amongst the other drugs which may be prescribed,in approved doses according to indications,are dilute mineral acids,euonymin solution,pepsin,lactopeptine,nux vomica,strychnine,bitter infusions,quinine,cascara,resorcin,carbolic acid,aniseed-water,and soda mint-tablets.

Respiratory System.

Rickety children,we have seen,are specially predisposed to such respiratory affections as bronchitis, which,on account of its danger,should at once be prevented or treated.Should bronchial catarrhal symptoms be observed,the patient should be placed in his cradle near the fire,but duly protected from all draughts;the bedclothes should be plentiful,though light,as their weight impedes the already hampered respiratory excursions.The proximity of the cradle to the fire allows of the steam from a bronchitis or other kettle playing about the patient and moistening the air.Its good effects may be enhanced by placing a little cottonwool loosely in the spout of the kettle and now and then pouring a few drops of Friar's balsam or other antiseptic over it;the respiratory distress is usually soothed thereby and the breathing calmed.The erection of some sort of tent over the cradle,- in the absence of special appliances an unbrella answers very well,- the full effect of the medicated vapour is obtained.Cresolene,a coal-tar product,is perhaps the best of the other vapourising substances;it is best used in a special lamp procurable for the purpose.I am not particularly impressed with the advantages claimed for the old-fashioned linseed poultice.It is very heavy,untidy, needs constant renewal and cannot always be entrusted to the mother,who is often clumsy and ignorant over its manipulation.Apart from its expensiveness,antiphlogistine,- a preparation of kaolin,glycerine and an antiseptic,is a much better application.It has an appearance not unlike putty,and should be heated in the container,in a saucepan or other vessel,until it is hot enough to be borne comfortably by the back of the hand.It is then spread, to the thickness of about an inch,over the infant's chest rapidly with a spatula,and is then covered with a large piece of cottonwool.Then the sides and the back of the chest are similarly dealt with,and a wide flannel bandage keeps the whole in place.This application is very much lighter than the linseed poultice,and it requires to be renewed only every twelve hours or so.The bronchial tubes should be stimulated to free secretion, though without depressing the circulation.The bowels should be freely acted upon at first,and then some such mixture of the following,two teaspoonfuls every four hours,administered:Solution of the acetate of ammonia (3ii),nitrate of potash(gr.xxxvi),glycerine(3iv),and water(ad ℥iii).Eustace Smith favours a mixture containing iodide of potassium(gr.v),nitrate of potash(3i), solution of acetate of ammonia(3iii),syrup(℥i),and cinnamon-water(ad ℥iii).When the cough becomes easier, the child may be given two teaspoonfuls every four hours of a mixture of ipecacuanha wine(m.xxx),ammonium carbonate(gr.xii),honey(3iv),glycerine(3iv),and water(ad ℥iii). Should the heart shows signs of enfeeblement,every four hours the child should be given a teaspoonful of a mixture containing ammonium carbonate(gr.i),tincture of

digitalis(mvi),syrup of Virginian prune(m.xx),and aniseed-water(ad 3i).If there is at the commencement of the bronchitic attack much obstruction from tenacious mucus,a teaspoonful of ipecacuanha wine will cause the expulsion of much of it by exciting vomiting.Mustard and other counterirritants may,if necessary,be applied to the chest.The condition of the heart should be carefully watched,and if cyanosis be observed,a little brandy should be given now and then.Sometimes nitroglycerine is useful in heart failure with congestion of the lungs,the average dose being 1/500 of a grain every hour or so, according to indications.Bronchopneumonia is one of the most dangerous complications of rickets,and always calls for careful management.The bronchitis kettle is useful when the bronchial secretion is deficient,and mustard ~~and~~ or other counterirritants are indicated.Antiphlogistine is useful,and the bronchial tubes may be cleared with ipecacuanha wine,tartrate of antimony or other emetics.Aconite and squills are apt to be depressing and must be prescribed only with great caution.Acetate of ammonia and bicarbonate of potash,or the iodide of the latter,are of value in rendering the mucus less sticky; and,even at an early stage,nux vomica or digitalis may be combined with these.When free secretion is established,hot applications may be discontinued,and the chest wrapped in cottonwool and ammonium carbonate and digitalis prescribed.The temperature must be watched;tepid sponging is the best way to reduce it,at least in private practice where the parents object to the use of the cold bath or wet pack.Rachitic patients do not usually bear ordinary antipyretics well.When emphysema or collapse of the lungs occurs,it is sometimes beneficial to apply two or three leeches to the front of the chest over the cardiac region,and after they come off mustard plasters or leaves may be used.Creosote preparations are of service,especially when gastrointestinal troubles coexist.The diet should be arranged according to the lines already laid down,and an occasional dose of grey powder or calomel does good.Stimulants are necessary from the first,and may assume the form of whisky,brandy, wine whey,or egg mixture;infants sometimes show a marked tolerance for these.The condition of the pulse will give a clue to the dosage and desirability of alcoholic exhibitions.If the pulse is weak,compressible,rapid or irregular,stimulants are indicated;also if there is pallor or lividity.They are most useful at the crisis of the disease,if the temperature falls suddenly,or if there is any sign of pulmonary collapse.Nitroglycerine,in the above-mentioned dose,is of service in collapse cases;as also is strychnine,1/300 of a grain of which may be given hypodermically to a child of a year old.A hot mustard bath may be employed,and the dose of alcohol may be increased,if necessary;if the child is unable to swallow, the alcohol may be introduced into the mouth by means of a glass syringe with an elastic nipple.Caffeine and atropine also are useful as respiratory stimulants,the dose of the former being 1/20 and of the latter 1/800 of a grain.Massage of the chest is indicated,as is also the inhalation of oxygen in desperate cases.At the commencement of the attack an emetic often does good by clearing out the tubes,a teaspoonful of ipecacuanha wine being the best form assumed.Depressants should always be avoided.During convalescence such tonics as

iron, quinine, and cod-liver oil are indicated, and a change of air, to the seaside or other place, may complete the cure.

Nervous System.

For the sweating of the head, in addition to the ordinary rachitic measures, it is advisable to make use of sponging with vinegar and water, or a dusting powder of equal parts of oxide of zinc, boracic acid and starch. The patient should have a hair or air pillow, these being preferable to one of feathers. Much benefit may sometimes also be derived from the nocturnal application to the head of the liniment of belladonna or doses internally of tincture of belladonna. As children tolerate this drug very well, as much as twenty minims may be given in one dose to a child of one year, or ten minims may be administered three times a day. A minim of atropine solution at night sometimes checks the perspirations of the part; phosphorus is said to act well, and Stoltzner used suprarenal extract. Alcohol is sometimes of service also in these cases.

Rachitic children are apt to be very restless at night and to suffer from night terrors and insomnia. The room should be darkened and kept quite quiet, and the condition of the gastrointestinal canal corrected. Some effort should be made to tire the child by games or amusements before retiring.

The occurrence of general convulsions are very suggestive of the presence of rickets in cases over six months of age. They must have immediate treatment, which may take the form of a hot bath and clearance of the bowels with castor oil or other aperient. To prevent them cow's milk, suitably modified, should be given in preference to patent foods, and, especially if there is constipation, the bowels should be regulated with suitable doses of grey powder or calomel. Cold douching of the spine, after the morning bath, is of great service in giving the necessary tone to the nervous system - in addition to which the child should be kept out in the open air as long as possible each day. When they do occur, in addition to clearing out the bowels, the gums should be lanced if there be difficulty in cutting the teeth; drugs should not be used unless absolutely indicated. Chloral, in doses of one to one and a half grains, sometimes is more effective than the bromides, which latter must be given in large doses to be ofuse. During the time that the child is in the hot bath, cold water may be poured upon the head. The violence of the attack may be relieved by hypodermic doses of the solution of the hydrochlorate of morphia (one minim), but chloroform or nitrite of amyl may have to be prescribed before the convulsions will cease. The foundation rachitic disease must be efficiently treated: otherwise the convulsions will return and in time, if the patient survive, actual epilepsy or mental enfeeblement will occur. Iron, quinine, cod-liver oil and general tonics are strongly indicated; and in all cases the question of dietetics and alimentary hygiene must receive the most careful attention.

The occurrence of tetany or motor spasms in rickets is evidence of the disturbed and excitable condition of the nervous system obtaining. Any gasfrointestinal condition of irritation should be promptly removed by means of calomel or grey powder. If intestinal worms are present,

they should be expelled with santonin or other vermifuge, calomel or grey powder being useful also in these cases. Warm baths are effective in relieving the spasms, and the general nutrition of the patient must be promoted on the usual lines. Drugs do not seem to do so much good, though bromide of potassium, chloral, belladonna, and physostigma preparations may be of use. Frictions with stimulating embrocations tend to alleviate the condition. Thomson (Practitioner, Oct., 1905) recommends cold douches once or twice a day, and he thinks it safe to administer a grain or two of antipyrin occasionally according to the age and circumstances of the patient. Stoeltzner (Jahr. f. Kinderh., June 11, 1906), having observed that the addition of chloride of calcium to infants' foods gave rise to increased irritability of the nerves and aggravation or return of the tetanic spasms and that the other inorganic constituents of milk, the sodium chloride and magnesium carbonate, did not do so, concludes that the frequency of tetany in artificially-fed infants is referable to the use of cow's milk in which there is five times as much calcium as in the maternal supply - in addition to which, he says, there is an excess of lime circulating in the blood left over from the processes of calcification in this disease. I am no believer in thyroid extract, which still has its advocates in obstinate cases; and the experienced observer mentioned above considers it quite useless, stating that there is no functional insufficiency of the parathyroids in this disease, tremors, twitchings, tachycardia, albuminuria or somnolence - which follow extirpation of this gland - being absent in rachitic tetany; further, there is the important difference that a milk diet aggravates the rickety tetany, whereas it has been shown by animal experimentation that the contrary obtains in parathyroid extirpation.

In the case of laryngismus stridulus the treatment must be conducted on similar lines to those already laid down. The mother should be warned that very little may bring on an attack, such as the reflex irritation from a draught of cold air or the debilitation of being kept in badly ventilated or overheated apartments. Gastrointestinal irritations are also operative, and these should be removed at once. The attacks of this distressing accident may usually be prevented or relieved by splashing cold water in the child's face; or the patient may be vigorously shaken to induce reflexly the proper function of the respiratory apparatus. Ashby recommends that the epiglottis be hooked back with the forefinger. In summer the infant should be placed in an empty bath and be rapidly sponged over with water at a temperature of 65.F.; but in winter he should be immersed in warm water during the cold spongings which should be performed three times a day. The patient should be out in the open air as much as possible, and any source of irritation in the bowels should be removed. Calomel and grey powder are here useful also, and strict attention should be given to the dietetic indications. Antispasmodic drugs are of service in certain cases, and a third of a grain of musk may be given to a child of one year every six hours. The tincture of belladonna, in the above-mentioned doses has its advocates, and Holt favours the administration of antipyrin in two-grain doses, every four hours, to a child of twelve months. The bromides or chloral may relieve the spasm; and during the attack it is useful to excite vomiting by tickling the fauces. The application of a hot sponge to

the throat is beneficial,and it is sometimes necessary to check the spasm with chloroform anaesthesia.The underlying rachitic condition must,of course,receive due attention.The food should contain an abundance of fat or cream,and great attention should be given to the general hygiene of the case.Cod-liver oil,iron,phosphorus,etc.are useful;and debilitated cases may need the administration of brandy,of which Cheadle recommends the following doses:

5	to	10	drops	every four hours	for	an	infant	1	month old.
10	"	20	"	"	"	"	"	2	months "
20	"	30	"	"	"	"	"	3	" "
30	"	40	"	"	"	"	over	3	" "
60			"	"	"	"	"	4	" "

There is no satisfactory treatment for chronic hydrocephalus.Incision,puncture,aspiration,strapping, blisters and mercurial inunctions have all been tried and found wanting - the fluid simply returning again. Henoch(Lectures on Children's Diseases,Voli,p.307)recommends local bloodletting by means of leeches behind the ears and temples,as well as purgative doses of calomel(gr.$\frac{1}{4}$-1 several times a day).To absorb the effusion he also prescribes small doses of grey powder,mercurial inunctions,painting with iodoform collodion,and the long-continued exhibition of iodide of potassium.

Miscellaneous Measures.

The dieting and the general measures already outlines are clearly indicated for the relief of the muscular debility and other anomalies obtaining in rickets.Formic acid and the formates have their advocates for the muscular asthenia;they may be combined with the glycerophosphates or other tonics,in proprietary or general form.Clement has tried formic acid and finds that the muscles are strengthened under its exhibition; that it relieves the tremor of the muscles and asthenia thereof;that it tones these structures;and that it abolishes the sense of fatigue;the appetite and general mental and somatic activity are increased as well.Strychine or other tonics may be combined with the elixir of coca.Ewart(Brit.Med.Jour.,1906,p.922)speaks highly of adrenalin solution in the treatment of muscular weakness;it gives a half to one minim in a drachm of water three times a day between meals.The thymus,the thyroid, the suprarenals,and the bone-marrow have all,as we have seen,been tried for the cure of rickets;but the best present-day opinion would seem to lead to the conclusion that too much reliance should not be placed upon therapeutic measures,the best and most lasting results being forthcoming from the diet,the environment,and the general management of the patient at an early age.

MANAGEMENT OF THE DEFORMITIES.

The treatment of the numerous and varied deformities of rickets involves vast surgical possibilities, which are obviously out of place here,though a short account of the management of the more important may be given. Once the deformities of the bones have become thoroughly established,the services of the surgeon will be required;but much can be done by way of preventing their occurrence,and on the lines already laid down. During the softening stage the bones may be coaxed or forced into correct alignment,but after the hardening process some surgical operation will be required.Frequently,however,the patient need not be operated on,as

rachitic deformities tend sometimes to cure themselves under careful and well-directed general treatment or measures directed to meet special indications as from time to time arising.

Head.

The bosses on the cranial bones tend to cure themselves in time; but when they do not, they should be left alone, as they are scarcely noticeable during life.

Spine.

The spinal deformities of rickets are forward or backward curvatures, with or without lateral twisting. They are due not to disease of the vertebrae, but to weakness of the muscles and ligaments concerned; and if untreated, permanent humpback or other conditions may remain. Kyphosis, with or without lateral curvature, is usually seen in children before they have commenced to walk. Lordosis is secondary to deformity of the lower limbs; Kyphosis from weakening of the muscles and ligaments of the back, and consists of a general rounding of the dorsal spine, and can be easily distinguished from bending due to caries of the vertebrae by the absence of angular gibbosity seen in the latter affection, by the presence of other rachitic signs, and by the fact that the rounding can be reduced by laying the infant face downwards and gently pulling on the legs. In addition to this, there are no signs of abscess, pain or paralysis. Lordosis may be mistaken for a secondary deformity due to disease of the hip-joint or a congenital dislocation of that part; but a careful study of the case will soon effect the desired differentiation. When spinal deformity is feared, the infant should not be allowed to sit up in bed until the normal tonicity of the spinal muscles is beyonf doubt. It should not, however, go without the all-important fresh air, but be carried about on a pillow during the time that it would otherwise be in the open air. Regular massage of the weakened muscles should be performed, and the usual cod-liver oil and other tonics should be employed. The massage treatment may advantageously be combined with cold douching of the spinal muscles, if the infant is over eighteen months of age - prior to that, hot water may be employed. Splints are not usually required, but in obstinate cases the special guttapercha appliance recommended by Noble Smith (Curvatures of the Spine, p. 29) may be employed, as it supports both the spine and protuberant abdomen. For older children Epstein has devised a very useful rocking-chair, in which the patient sits in such a way that the body-weight is taken off the limbs and the spine receives due support. I am not in favour of using plaster of Paris jackets in these cases.

Pelvis.

Preventive measures are here of some service, and must be carefully instituted in the case of female children with a view to warding off such deformities as are likely to interfere with parturition in after-life. During the softening stage the child should be kept in the recumbent position, so that all distorting weight may be taken off the yielding bones. But the patient's position should be frequently changed or a little walking exercise be allowed, as the constant lying on the back may lead to a separation of the pubic symphysis.

Extremities.

For the prevention of the deformities of the

limbs the child should not be allowed to walk, but have a proper amount of rest, with massage, tonics, and the other measures described; then splints may not be required, though they must not be neglected when relief cannot otherwise be obtained.

Femur.- The shaft of this bone is usually curved forwards, though it may be bent to the outside as well. The result of this is that the thighs are widely separated, the patient is short and stunted in appearance, and there is usually co-existent knock-knee or bowleg. The preventive treatment consists of keeping the child from walking during the stage of bone-softening and the avoid-ance of carrying the child in the arms, unless on a pill-ow or cushion. Incurable cases should have the part cut down upon and the bone straightened by the usual means; this is the operation of osteotomy nowadays very frequently and successfully performed. The hip-joint deformity, known as coxa vara, is a condition in which there is downward and forward depression of the neck of the femur; it is the direct result of the weight of the body acting on the softened bone. The leg is shortened, there is limitation of abduction, and perhaps diminution of the power of internal rotation; but there is no marked interference with the function of the limbs. The treatment, apart from the general and special measures directed towards the cure of the underlying disease, consists in forbidding walking and fixation of the part in a specially devised splint such as described in the surgical works. Only in severe cases, and in those in which the bones have undergone complete ossification, will the operation of osteotomy be required. Knock-knee, or genu valgum, may be the outcome of deformity of the lower end of the shaft of the femur,- sometimes to a tibial anomaly,- premature synostosis of the outer half of the growing line, or it may arise from yielding of the soften-ed ligamentous structures. The operation of osteotomy is required in the well-established condition.

Tibia.- Genu varum, or bowleg is usually observed in one extremity with genu valgum on the other. It results from the pressure of the weight of the body above on the part. It may be prevented by keeping the child in the recumbent position or by the application of special splints. Incurable cases require operative measures.

Feet.- The prevention of flat-foot calls for rest and the provision of special boots described in the surgical works. The part should also be regularly massaged. Intractable cases require the usual osteotomy.

Clavicles.

Here, as elsewhere, fractures of the greenstick variety may occur; and on this account the rachitic child should be very carefully handled or exercised. When a fracture does occur, splints or other orthodox measures are required; and in every instance the underlying rachit-ic dyscrasia must be treated.

Ribs.

The tendency of these bones to undergo fracture must be borne in mind, and the fact that the depressions of the various grooves and other already-described costal anomalies may give rise to chronic bronchitis must not be overlooked. All the muscles of the part should therefore be submitted to regular massage or embrocation stimulations, and the child should be prevented as much as possible from falling on the part. Crying or screaming will do good, and the due inflation of the lungs may also

be promoted by the blowing of toy-trumpets or making soap-bubbles.The abdomen should be enclosed in a well-fitting binder,the object of this being the support of the weakened belly,retardation of totally-diaphragmatic respiration,and encouragement of the thoracic act.The binder should be frequently removed to prevent irritation or displeasure,and in no case must it be worn if it proves harmful or gives rise to great distress.

Arms.

The occurrence of deformities of the arms should be prevented by the prohibition of the child's crawling about on the floor unduly.The deformities here observed are not usually so severe as to interfere with the functions of the part or to call for operative inter-ference,such distorsions as do occur being the result of crawling or sitting with the weight of the body on the arms.Splints are sometimes required,and in occasional cases osteotomy may have to be performed.

CONCLUSIONS.

Rickets is a general disease of malnutrition, widely prevalent in children, which, were the dietetic, social and other conditions in early life obtaining anything like intelligent or ideal, should not exist - or at least only to a comparatively trivial degree.

The date of its real origination remains hidden in the misty times of remote antiquity, and it is to the seventeenth-century observer, Glisson, that we owe the foundation of our present knowledge of the disease.

The pathology of rickets has been summed up in the oft-cited aphorism that it is "an exaggerated preparation for ossification and a diminished accomplishment of it;" the osseous anomalies being the most conspicuous phenomena of the disease. These may affect any of the bones, but are best known in connection with the cranium, the ribs, and the limbs - there being, in the case of females especially, pelvic deformities which have a very important bearing on childbirth in after-life. Yet there is an underlying dyscratic perversion which may also find expression in various signs and symptoms in connection with such organs as the brain, lungs, heart, blood, liver, spleen, and gastrointestinal structures.

The exact etiology of the disease has been, and is still mooted, though there is general agreement regarding the numerous and varied conditions which favour its development, amongst such factors being included heredity, age, sex, racial peculiarities, climatic and seasonal factors, local influences, insanitary conditions, exposure to cold, organopathies, malaria, syphilis, exanthematous or other acute debilitating affections, parental influences, a germ, and dietetic errors - the last-mentioned having attached to them a growing importance.

The disease pursues a characteristic course in the vast majority of instances, and the symptomatology of the affection is well recognised.

Various classifications of phenomena have from time to time been devised and are very convenient for the purpose of narration.

The osseous symptoms are of prime importance, and are the outcome of imperfect ossification, abnormal resorption of osteoid tissue and hyperplasia.

In the case of the head there are alterations in size, shape and fontanelle-closure, with perhaps grooving and not infrequently craniotabes, which, contrary to what was formerly supposed is peculiar to neither rickets nor syphilis. Dental anomalies and facial peculiarities are often observed.

The chest undergoes certain alterations, principally in the form of grooves, rosaries and pressure effects.

The pelvic deformities are of much importance in the case of females, and for the reasons described on page 58.

The various deformities of the limbs in rickets make their appearance when the infant attempts to crawl or walk, the weight of the body on the softened bones being responsible for the numerous distorsions which not infrequently arise - e.g., bowleg, knock-knee, and

flat-foot.

Marked flabbiness of the muscles and weakening of the ligamentous structures commonly arise, and find expression in enlargement of the abdomen, spinal curvatures, and the like.

The skin may be pale and flabby, and it is important to note that rickets is more or less of a fat-disease, even the mother being sometimes deceived by the plump appearance of the child and only present the latter for the treatment of gastrointestinal catarrh or other underlying rachitic condition.

The nervous affections may find expression in such dangerous complications as convulsions, tetany, and laryngismus stridulus. Sweating of the head may also be in evidence.

The tendency to bronchial or other respiratory lesions in rickets is well known as ever to be guarded against; bronchopneumonia is a by no means infrequent cause of death.

The heart may suffer from pressure effects referable to the distorted ribs, and the circulation in the blood-vessels is usually sluggish and poor, with anaemia in a large proportion of cases.

The digestive troubles of rickets are sometimes difficult to cure. The teeth are late in being erupted, the coating of the tongue usually indicates the abnormal conditions obtaining lower down, tonsillitis and adenoids are common; "pot-belly" and gastrointestinal catarrh are frequent, and the liver and spleen may undergo displacement or actual disease.

There are no characteristic urinary symptoms, though certain observers allege the contrary as regards the odour and performance of the micturition act.

Cataract is sometimes seen, especially during the teething period.

The temperature presents no abnormalities in uncomplicated cases.

Various forms of rickets have been described. The foetal variety is that seen at birth, the deformities sometimes being of life-long persistence. The congenital is marked by the tendency to fracture of the long bones. Acute rickets is sometimes of severe and sudden development, there being a multiple epiphysitis or periostitis of the articular ends of the long bones. It is said not to be pure rickets, but the latter in association with some scorbutic taint. Late rickets is characterised by the tardy appearance of osseous deformities, which are apt to persist for a longtime. Its exact nature is still in dispute.

Various <u>complications</u>, such as bronchitis and other internal affections, may at any time interrupt the normal evolution of rickets and prove a source of great danger to the child, and in convalescence, too, there are a number of intercurrent affections which may incapacitate or kill the patient.

The <u>diagnosis</u> of rickets is not usually difficult in view of the cardinal symptoms outlined, particularly the osseous and abdominal ahomalies. But there are certain indefinite or vague cases which maycause diagnostic confusion. Amongst simulating affections are syphilis, tuberculosis, worms, scurvy, chronic hydrocephalus, craniotabes of syphilitic origination, spinal caries, osteomalacia, congenital dislocation of the hip, cretinism,

pleurisy,tabes mesenterica,epilepsy,infantile paralysis, pseudohypertrophic paralysis,diphtheritic paralysis, and paraplegia.

Uncomplicated rickets very seldom causes death;it is therefore mostly of favourable prognosis,provided the proper prophylactic or actual treatment be of early institution.The earlier this is done the better.Once the disease gains a firm hold,there are all sorts of troubles which may hamper or terminate the life of the child.

Prevention is better than cure;and prophylactic measures should be of the most thorough sort and be directed to the supervision of the father,the mother and the infant.The entire training of the female child should have ultimate maternity in view,domestic management being assiduously instilled and an affection for, and practical interest in,children of all ages encouraged, with pride in the home appointments and everything which is likely to concern her future life.

The whole question of infant feeding is of very great importance in this disease.If properly instituted and effected at the maternal breast,rickets should not occur,maternal milk being the natural and usually ideal supply.

When it be deficient or unsuitable,a wet-nurse should be engaged,but under proper precautions as regards her general health and disposition.

Artificial feeding is apt to be a source of danger to the infant,and should be undertaken only when absolutely necessary.The food supplied in this way should as closely as possible in composition approach the breast milk.

It is therefore necessary to be familiar with the nature,value and uses of the various constituents of milk,which should receive careful and intelligent study and application in every case.

Vegetable and malt soups,buttermilk,lactobacilline, kephir,kumiss,matzoon,dextrinised gruels.egg mixtures, Ashby's food,peptonised milk,sterilised or pasteurised milk may be required to meet special indications.

Condensed milk is too rich in sugar and too poor in fat for general or routine use;it may be allowed for such occasions as a journey,but it must always be remembered that it is a prolific source of rickets.

Humanised milk may be prepared insuch a way that the composition is similar to that of the maternal secretion.

Walker-Gordon laboratories have been instituted in various parts of the country for the provision,according to prescription,of milk modified to the requirements of the child.These take into consideration particular needs and have been productive of incalculable good. Exact percentages are in vogue based on comparative standards.

The number of patent foods is legion.None of them, however,can take the place of mother's milk,or even properly modified cow's milk,and are more or less objectionable in their excessive carbohydrate content and their deficiency in bone- and tissue-making substances.

In all cases of artificial feeding it is very important that a proper bottle should be used,and that it so devised that it can be kept scrupulously clean and free from the risk of germ infection through neglect.

There is a proper way to hold both the bottle and the child during the act of feeding;and on these points the mother should be properly instructed.

During the second year of the child's age mixed feeding may be allowed,but there should be a dietetic method at this and all other times. After the second year the food may be of a much more varied character; and about now one or other of the numerous published diet tables should be adopted.In this way the child will be properly fed and at proper times - care being taken to meet any special therapeutic indications as they arise.

The hygienic treatment of rickets is of vast importance,fresh air,warmth,sunlight,proper clothing, rest,exercise,baths,etc.,having a great influence on the prevention and cure of the disease.

Rickets is a disease that cannot be cured with drugs;in short there is no specific medication.

Cod-liver oil is rather a food than a medicine,and it(or one of its approved substitutes)should be tried in every suitable case.

Phosphorus has been much recommended,but its ehibition is not always free from risk.The preparations of the metal are,however,not infrequently of great service,particularly the hypophosphites and the glycerophosphates.

Iron,arsenic,quinine,strychnine,etc.,are tonics which have their uses in this as in other diseases.

Massage and electricity are of recognised utility and applicable in a large proportion of instances.

The alleged beneficial effects of organotherapy in rickets are still in dispute.

For the rest,as Jacobi puts it,"it is air,air,and again air!"that is so strongly indicated.

The general treatment of the disease must,however, not be conducted to the entire exclusion of the control of the special symptoms and complications - for the relief of which much can be done with drugs and other means.

At all times the condition of the gastrointestinal tract must be watched,and any sources of reflex irritation promptly removed.

The tendency of rachitic children to respiratory affections must always be borne in mind and the utmost care taken to prevent their origination.When once in evidence,their treatment must be on orthodox lines, with due regard to the already-existing debilitation of the patient.

In connection with the nervous system the danger of death from the rather frequent convulsions must be remembered and their prevention aimed at by removal of recognised causes. Tetany requires treatment of the underlying dyscrasia and the disturbed and excitable condition of the nervous tissue.

Laryngismus stridulus is always a source of keen anxiety.Prevention is as important as cure.Reflex irritations must be forthwith removed,and during the attack antispasmodic measures should be employed,even to the extent of anaesthesia in certain instances.

Formic acid and the formates are said to have a markedly beneficial effect upon the muscular asthenia in this disease obtaining.

The correction of the once-established deformities

of rickets is the province of the surgeon;it is their prevention at which the pediatrist aims.Short of operation,-which should never be too hastily performed owing to the tendency of the disease towards cure under proper management,-they can be relieved by simple manipulation of the softened bones,as well as splints and a variety of orthopaedic appliances.

CASES

1.

H. J. K., aged six months, was born under normal circumstances, but very soon showed signs of anaemia after being placed on the bottle. It lost flesh for a time, but later developed a certain amount of flabby plumpness. Constipation was very troublesome and had to be relieved bythe introduction of soap into the rectum. The head was enlarged, the sutures were wide, and both the anterior and posterior fontanelles were larger than they should be. Over the frontal and parietal bones craniotabic patches were present. The epiphyses of the wrists and ankles were enlarged, and the loss of muscular power was marked. There was a decided history of rickets in several members of this family, and the subsequent course of the case was characteristic of the disease. The spleen underwent no enlargement. The milk was subsequently modified according to indications, the deformities were corrected on the lines laid down, and the patient ultimately recovered.

2.

M. McM., aged 17, had been ailing for some time before being seen, increased difficulty in walking being also complained of. He was fairly tall and of good proportions. Anaemia had for some time been in evidence; there was no rise of temperature, and rheumatism could be excluded. Late rickets was suspected, and on examination the epiphyses of the femur were seen to be considerably enlarged; the ankles were in the same condition. There was little or no pain or redness or swelling of the soft parts; and, though walking was difficult, the patient was by no means a cripple. The condition persisted for several months; but under rest, tonics, and especially cod-liver oil, a gradual improvement was observed, the osseous anomalies undergoing reduction and finally disappearing.

3.

J. J., aged three months, had from birth been reared upon the breast. About this time vaccination was performed and was successful. At the sixth month the child was again seen, when it was discovered that, for some trivial cause, the infant had been weaned in the meantime, cow's milk and one or other of the patent foods being given. It seemed to do badly from the very first and had repeated attacks of diarrhoea, was restless in its sleep, and was much troubled with head-sweating. The face seemed small in proportion to the size of the head, which had assumed a quadrate appearance. Anaemia and emaciation were observed, the muscles were soft and flabby, and the limbs seemed without the normal power. The rickety rosary was seen on the ribs at their junction with the cartilages, but no other osseous lesions could be made out. The abdomen was large and tympanitic; in short the early symptoms were present in their typical form. The child was given a mixture for the gastrointestinal catarrh, which it soon relieved. Percentage feeding was introduced, rest and exercise in the open air and hygiene were ordered, and in time there was perfect recovery without the manifestation of any of the dreaded deformities of the limbs.

4.

T. P., aged four months, had been reared from birth on the bottle and patent foods, and never seemed to do well. Though not exactly emaciated, great deficiency of muscular power was present. Vomiting, purging and other gastrointestinal disturbances were in evidence. Head-sweating at night was profuse. No lesions could be discovered in the osseous system. Grey powder alternated with calomel relieved the above-mentioned troubles, and frictions with cod-liver oil and open-air exercise were prescribed for the general condition. The patient seemed to do well for a time, but two months later had general convulsions which lasted for several nocturnal hours. The epiphyses were now seen to be enlarged in a typical way, and the bareness of the scalp over the occipital bone testified to the profusity of the head-sweating with which the child was troubled. Restlessness, head-nodding, and night-terrors had also been in evidence. The usual treatment was at once instituted and the patient recovered after a long and tedious indisposition.

5.

A. L., aged 1½ years, had been for the first year of its existence reared on the breast. He was the seventh child of the family and seemed to have done well until recently, though it was observed that no attempt was made at walking and that the limbs were inclined to bend under his crawling weight. Night-terrors, insomnia, head-sweating, gastrointestinal catarrh, etc., were not present, the bowing of the legs, enlargement of the epiphyses of the wrists, and beadings of the lower ribs being the only osseous rachitic lesions observed. The usual treatment was adopted and the patient ultimately recovered.

6.

B. M., aged 1 year, was the firstborn and had been breast-fed for six months, afterwards receiving artificial feeding owing to the undesirable maternal supply. The patent foods and cow's milk very soon produced an obstinate diarrhoea alternating with constipation, and the patient became fat, flabby and asthenic, making no attempt at walking. At night there was great restlessness, much head-sweating was present, and the bedclothes were thrown off almost as soon as comfortably arranged. The head was large and quadrate, the anterior fontanelle was widely open, and pendulous abdomen and rickety rosary were easily made out. Nothing else abnormal could be discovered. The proper treatment was advised and carried out, with the result that the patient recovered.

7.

V. H., aged 1½ years, had been reared from birth on Cow's milk and patent foods. At this time there was great enlargement of the epiphyses of the wrists, rickety rosary, and "pot-belly". There was a decided tendency to bronchial catarrh, for which the usual stimulant expectorants and tonics were prescribed. Some temporary improvement seemed to occur from these; but, on the third day of the medication, the child had several attacks of general convulsions, and died within twenty-four hours. A post-mortem examination was not allowed.

8.

W. F. H., aged six months, came of a tuberculous stock, the father having died of consumption of the lungs three months ago; the rest of the family were very delicate. The patient had been fed from birth on cow's milk and proprietary dietetic preparations and soon became fat and flabby, restless and irritable. Obstinate constipation was also present. At this time there was an alarming attack of general convulsions, induced, it was said, by the administration of some very hot liquid. During the next three months the patient had no less than six similar attacks, gastrointestinal catarrh being present all through. This was duly treated and ultimately disappeared; the patient seemed to do well, and began to cut the teeth without convulsive or other disturbance. Late one night general convulsions suddenly occurred, after a day of excitement and overfeeding, and, despite hot bathing and the like, death occurred.

9.

W. L. L., from the age of six months suffered from severe rickets, osseous troubles and gastrointestinal catarrh of somewhat severe type; the brunt of the attack seemed to fall on the bones and respiratory system; and, being improperly treated, tended to chronicity. The patient suffered from chronic bronchitis for many years, this being particularly severe during the winter months. He was first seen at the age of twenty-one, when he presented marked deformity of the chest; it was flattened on each side below the armpit, and the forward projection of the breast-bone gave him the appearance of pigeon-breast, with deep grooves on either side running from above downwards. These anomalies were not without effect upon the position of the heart, that organ being displaced towards the right and the apex-beat moved correspondingly from its normal position. The head was large and presented many bosses. One leg was bowed and the other showed knock-knee. Spinal curvature gave the patient the appearance of a humpback dwarf. Beyond the prescription of stimulating expectorants and embrocations for the chest trouble and general advice, nothing was done.

10.

E. O., aged 1 year, had been reared from birth on Cow's milk and proprietary foods, which resulted in his attaining a large size. He was fat enough for a baby exhibition, but on examination it was seen that this was merely a rachitic expression and coincident with gastro-intestinal catarrh and beading of the ribs. He was at once placed on the percentage method of feeding and ordered to have an abundance of fresh air and freedom from excitement, as indicated by the occasional muscular tremors and tendency to nystagmus observed. He rapidly improved, but at the age of eighteen months, having been out late one night, contracted bronchitis, which culminated in lobular pneumonia. For t is he was treated in the usual way, especially as regards the bronchitic kettle and stimulants. He survived this attack, but six months later again developed bronchitis from the same cause. This was of long duration and after recovery he seemed little the worse for his trying experiences. Special dietetic precuations, in the way of regularity and desirable composition of meals as per chart already given, were adopted, and the patient is now free from the disease.

11.

I. M. C.,aged ten months had been fed on the milk- and patent-food-bottle from birth owing to the poor quality and quantity of the maternal supply.Signs of rickets made their appearance at the sixth month.The ribs became slightly beaded,and the epiphyses of the wrists were somewhat enlarged.Constipation alternated with occasional diarrhoea,and one convulsive attack was experienced.A somewhat troublesome cough now appeared, especially at night,the attacks of which usually culminated in vomiting;it lasted for a fortnight,and during this time the temperature was one degree raised.The usual auscultatory signs of bronchitis were present,and after a few days pertussal manifestations were observed.These coughing paroxysms occurred several times a day,and on very slight excitation;the nose and mouth were filled with a very sticky material which was with difficulty expelled.The sufferings of the patient became aggravated and death in general convulsions occurred.

12. A. K.,aged fourteen months had been reared on the breast until four months ago,when indigestible articles from the family table were allowed.The usual signs of rickets now appeared,such as enlargement of the head and epiphyses,patency of the anterior fontanelle,beading of the ribs and protuberance of the abdomen.The patient contracted measles from another child living in the same room;the attack was severe,and on the fifth day signs of bronchopneumonia appeared.This was vigorously treated on orthodox lines,and the patienttook the turn for the bett-er at the end of the week and ultimately recovered. A proper dieting was introduced,and the rachitic signs were in due course allayed.

13.

L. T. L.,aged sixteen months,had been fed on cow's milk and patent foods from birth,and at an early age a tendency to diarrhoa was observed. The child seemed disinclined to walking attempts,but appeared to be about normal in other respects;the plumpness deceptive as is usual in these cases.The teeth were rather ill-shaped, and very soon took on a tendency to decay.There was a certain amount of enlargement of the epiphyses of the wrists,and the lower ribs showed beadings.The abdomen was enlarged somewhat.But for the presence of diarrhoea rickets might not have been suspected.The diet was at once corrected and the further development of the affection checked thereby.On return from the seaside the child seemed perfectly recovered.

14.

J. S.,aged eleven months,had until quite recently been suckled by his mother.Artificial feeding was adopted and this almost immediately led to restlessness,sweating of the head at night,and a slight erythema about the face.The ribs were beaded a little,there was a small degree of enlargement of the epiphyses of the wrists,and the crying of the child on handling suggested tenderness of the bones.The stools were frequently voided and had a very unpleasant odour and a greenish colour.The mother was a small delicate woman quite unfitted for the performance of the natural dietetic function,and during the last week of the act the infant lost nearlytwo pounds in weight.Percentage feeding and tonics were prescribed,and

raw meat-juice was ordered.The child improved rapidly and very soon regained the normal weight for age;the progress was uninterrupted,and recovery ultimately occurred.

15.

W. McN.,aged 1 year and born of a rachitic mother, developed constipation,alternating with diarrhoea,and sweating of the head.At the age of twenty-one months the patient commenced to walk,and then bending of the leg bones occurred.The first tooth was cut at the age of ten months,and the rest of the alveolar products were slowly and irregularly erupted and assumed abnormal shapes.The artificial feeding on patent foods,which had, owing to the poor supply of the mother,been instituted unintelligently from birth,was prohibited and the percentage method adopted on home-modification lines - with the result that the further progress of the disease was checked.

16.

I. H. L.,aged 6 years,was born with fractures of both collar-bones and of the right humerus;there was also cleft-palate.The patient was unable to walk at the normal age,and when two years old the back began to bend.The child had been fed on condensed milk from birth, and it was not until the end of the third year that an inclination for walking was noticed.With the exception of grooving,the chest at present seems well formed,but the legs are thin and stunted in growth.The wrists and ankles are markedly enlarged and both legs are bowed. The intelligence is decidedly deficient and future idiocy is feared.

17.

B. D.,aged ten months,and artificially fed from birth developed rachitic phenomena,such as sweating of the head,diarrhoea,enlargement of the abdomen and wrists and ankles,lateral grooving of the chest and rickety rosary.Walking is delayed,and the characteristic rachitic expression is present.The patient was placed on proper diet,including raw meat-juice,bone-marrow and extract of malt.The diarrhoea ceased,the sweating of the head disappeared,and very soon attempts at walking were made.

18.

C. G.,aged of healthy and affluent parents and was reared on the breast until the age of six months,when a diet of cow's milk and patent foods was adopted.Then the previously bright and happy infant developed diarrhoea and early rachitic signs.One night it was out in the cold and wet,with the result that there appeared pain in the right and left ankles and knee.A few days later the epiphyses of the wrists and ankles showed a tendency to swelling,and the patient became anaemic and flabby. The improper diet being persisted in,there were observed ecchymoses on the tibia,and soon the gums,especially the upper ones,became scorbutic,bled and swelled up so as to cover the teeth.The gums covering the alveolar processes where there were no teeth participated in the disease.The patient was now placed on modified cow's milk,and was also prescribed lemon-juice and vegetable soups.A rapid recovery was observed.

19.

T. M., aged nine months had been reared on cow's milk, condensed milk, and occasional doses of patent foods from birth, with the result that about the age of six months the osseous and gastrointestinal signs of rickets were observed and duly treated. The patient seemed to be doing well, but one day he suddenly gave a short cry and lapsed into unconsciousness and became convulsed. The spasms were general, though affecting one side of the body, the right, more than the other. The head was drawn to one side, and the eyes were fixed and drawn upwards. The hands were clenched with the thumb in the palm, and the whole body was in a state of tonic contracture with flexion of certain parts. After a bried period this condition was followed by clonic spasms. The conjunctival reflexes were abolished, and the pupils were dilated. The urine and faeces were involuntarily voided. This convulsion was succeeded in rapid succession by others extending over a longish time, and the patient seemed afterwards exhausted and unable to move his limbs. These attacks occured every other day for a week, but during the intervals the mind did not seem impaired. The treatment consisted of immediate immersion of the patient in a hot bath, dosing with chloral and during the acme of the seizure a whiff of chloroform. During the intervals the bromides were tried, and at the end of the week cod-liver oil and peptonate of iron were administered. The attacks did not after this return, and the patient ultimately grew up into a strong and healthy child.

20.

K. S. H. aged 1 year, had been rachitic from the time of cutting the first tooth at the age of six months. The usual milk modification was instituted, but imperfectly performed by the stupid mother. He seemed to be doing faily well, however, but one night, after a day of excitement and constipation, he suddenly developed laryngismus stridulus, after a short warning in the way of slight crowing sounds. During the attack the breathing seemed to be completely arrested. The chest was fixed; the head was thrown backwards; and the face, at first pale, soon became cyanotic; the eyes were widely open and staring. Some twitching of the facial muscles was observed. There seemed also a tendency to opisthotonos, carpopedal spasm, and general convulsions. The attack lasted less than one minute, and during it the patient seemed about to die from impaction of the epiglottis. The deepening cyanosis culminated in a relaxation of the spasm; the air slowly entered the lungs again through the imcompletely relaxed glottis; there was a characteristic prolonged, high-pitched and crowing sound, and the attack ended in a spell of coughing and crying. The absence of pyrexia, hoarseness and cough after the attack, the suddenness and completeness of the arrest of respiration, the short duration of the paroxysm, the peculiar crowing inspiration in which it ended, and the associated convulsive phenomena, constituted a characteristic clinical picture which could not be mistaken for any other affection. During the attack the patient was kept in the sitting position. Cold water was dashed over the face and chest and the skin of the trunk was lightly slapped with a wet towel. Smelling-salts were held to the nose. Ice was applied to the pit of the stomach with a view to exciting the inspiratory

effort,and for the same purpose a large sponge moistened with hot water was held against the throat and upper part of the chest.Meanwhile a hot bath had been prepared, and the child was placed in it,while the cold water was at the same time poured over the head and neck.An attempt was made to release the impacted epiglottis by the passage of the forefinger into the throat.Chloroform anaesthesia was not required.The patient's general health was duly supervised after the attack,and the angry-looking gums were incised.The bowels were kept open with castor oil and calomel.Daily tepid baths,with cold sponging of the chest and back,abundant fresh air,cod-liver oil,the syrup of the iodide or iron,and careful regular feeding were also prescribed.

21.

H. E. J.,was born under normal circumstances,but was reared upon the bottle owing to the death of his mother soon after he was born.He began to suffer from diarrhoea and vomiting and rapidly lost weight.This was duly prescribed for and he continued to improve,though the marasmic condition persisted to some degree and dyspepsia was troublesome.He seemed to do best on modified milk and barley-water.At the age of three months sweating of the head was observed,as well as restlessness and kicking off the bedclothes.There now appeared slight enlargement of the epiphyses,some beading of the ribs,and thickening of the frontal bones.Anaemia became pronounced,which iron preparations did not relieve,only Virol and similar preparations.Under this treatment the disease gradually abated and recovery ultimately occurred.

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